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THE

MAGAZINE OF POPULAR SCIENCE,

AND

JOURNAL OF THE USEFUL ARTS.

ON THE STEAM-ENGINE.

By M. Arago.

[Independently of the copious and valuable information upon the universally-interesting subject of the Steam-Engine which is contained in the following paper, the circumstances under which it has been given to the world, and the probable ultimate consequences of its publication, combined with the reputation and the final aim of its eminent author, will endow it with a lasting importance.

It may be thought superfluous, if not impertinent, at the present day, to say who M. Arago is, or to describe his position and influence in the scientific world. We pass on, therefore, to his paper, and Englishmen must not stand unconcerned, when he stretches out his powerful arm, to obliterate the honour, now almost sacred by age, of an ingenious compatriot, and to extinguish a very brilliant star in the constellation of national glory. Such is the aim of M. Arago.

The *Annuaire* of the *Bureau des Longitudes* of France, always distinguished for the accuracy of the information it contained, has been for several years increasing in reputation and circulation, and that at an accelerating rate, in consequence of the "*Notices Scientifiques*" which have been annexed to it. The ability with which these have been executed, and the importance of the subjects treated in them, are of a very high order. The members who compose the *Bureau des Longitudes* are the *élite* of France. They were, in January, 1837,

Geometricians:—Poisson, Le Baron de Prony.

Astronomers:—Bouvard, Lefrançais de Lalande, Arago, Biot.

Retired Navigators:—De Freycinet, Le Baron Roussin.

Geographer:—Beautemps-Beaupré.

Artist:—Lerebours.

Assistant-Astronomers:—Mathieu, Le Baron Damoiseau, Savary, Largeteau.

Assistant-Artist:—Gambey.

It is the duty of this corps of *Savants* to prepare the *Annuaire*, and having done so, they present it annually "Au Roi." We may, therefore, safely presume, that any article admitted into its pages, must have passed no common ordeal of examination, and once found there, would be received by a vast majority of its intelligent readers, with the most implicit confidence. Such is the organ which is now bearing for the *second* time, and on a wave continually expanding, the representations and the reasonings of M. Arago.

It was in 1829, that the first paper of M. Arago on the steam-engine was published. The *Annuaire* of that day had comparatively few readers in England. Still, at that period, it was gratuitously sent to several learned bodies and persons to whom the reputation of English science ought to have been dear, but the public expression it then excited was so feeble and transient, as more to resemble the sob of a vanquished gladiator, than the indignant cry of invaded honour.

It is true, that in the course of the same year, Mr. Ainger, an architect, and much the junior of M. Arago, published, in the *Journal of the Royal Institution*, the substance of two lectures delivered by him in the Theatre of that Establishment, in which the claims of M. Arago for his countrymen were examined, and both them and their author treated with some severity.

The subject, we believe, was never afterwards publicly noticed in England, and for several years the state of opinion upon it was probably as follows :—M. Arago, and all the French, and the far greater part of the continental readers of the *Annuaire*, were convinced that the *coup-de-grace* had been given to the fame of the Marquis of Worcester, while nine hundred and ninety-nine, at least, out of a thousand of the Marquis's countrymen, who would have felt that his reputation ought to be defended, were totally unconscious of the blow!

The effect of Mr. Ainger's paper upon M. Arago was to nettle the latter to a most painful degree, and during the irritation he laid Mr. Ainger on the critical dissecting-table, and most probably "cut him up" as perfectly as was ever accomplished by vengeance the most ruthless, assisted by power the most formidable, and science the most refined.

Fortunately, perhaps, for both gentlemen, this operation on Mr. Ainger was of a nature that could not be admitted as a "*Note Scientifique*" in the *Annuaire*. M. Arago cooled, and he abandoned the idea of publication. His victory over the Marquis he still considered unimpeached, and this reflection might be favourable to his return to indifference with regard to Mr. Ainger. But the manuscript which contained the indignation of M. Arago was not destroyed—it lay slumbering in an inflammable atmosphere;—a spark from the other side of the Atlantic set it in a blaze. The explosion which has followed, may be a little less annoying to Mr. Ainger than that originally intended, but it will be quite as fatal in its consequences to the fame of the Marquis of Worcester, and to the national glory, if the blow of M. Arago be not parried more successfully.

That there may be, on our side of the water, no pretence of ignorance of the attack, we present the article of M. Arago to our countrymen, carefully translated, and we give it uninterrupted by observation or note of our own of any kind, in order that it may have the full force which its distinguished author intended; reserving, of course, the right of discussing it afterwards, as freely as we may think proper. Further, in order that no doubt may be entertained as to the degree of correctness with which M. Arago has translated his quotations from English authors, we shall give these translations in his own words, and accompany them with the original passages.

Here then, is an antagonist, an arena, lookers-on, a cause, and a guerdon, which may tempt the most fastidious, and must provoke the least patriotic, knight-errant, in the cause of British priority of invention.

We have no fear that champions will be wanting, though we confess we dread the powers of this French "wrestler." We do not, therefore, pretend to have no doubt of the issue, or to look with indifference on the contest, nor shall we escape deep mortification if an "Orlando" do not appear for England in such a field. Still, premising the old English condition of "clear stage and no favour," we shall, as lovers of truth, and in the true English spirit of a modern Hero of another Ring, say, (with a slight paraphrase) "*May the truth prevail*[*]."

When we reflect on the immense services that the steam-engine has already rendered to manufactures and navigation, we shall not be astonished at the earnestness with which inquiries have been prosecuted as to the share that may be justly claimed by various nations in this admirable invention. Still it will not be learnt without surprise, that in England alone, the booksellers have sold, within a very few years, more than a hundred thousand copies of the numerous works in which this historical question has been discussed. So prodigious a sale is owing, I have no doubt, principally, to the lively interest that the steam-engine must naturally excite in a country where it is met with at every step; but perhaps we may be permitted to suppose that national pride may have had some share in it. In fact, whether we discuss the subject with the Member of the House of Peers, or the mere artisan,—the banker of the city whose brilliant speculations have led him into every region on the globe, or the farmer who never set foot out of his native county,—in the immense manufactories of Birmingham, of Manchester, of Glasgow, or in the humblest workshop of the cottage, everywhere you are told that the Marquis of Worcester is the first inventor of the steam-engine, everywhere they cite, in addition to this name, the names, *all English*, of Savery, of Newcomen, of Beighton, of Watt, of Hornblower, of Woolf, &c. And in general, authors and persons specially devoted to the cultivation of the sciences, have, upon this subject, opinions not less decided. If you open the recent Encyclopædia of Dr. Rees, you will there find this passage. "La machine à vapeur vient immédiatement après le vaisseau, dans l'échelle des inventions; mais dans une Encyclopédie Anglaise, elle doit occuper le premier rang, à cause qu'elle à été entièrement (*wholly*) inventée et mise en pratique par nos compatriotes."—(Art. *Steam Engine*[†]). and eleven lines lower, as if the first passage were not sufficiently explicit, "La machine à feu a été inventée par un petit nombre d'individus, *tous Anglais*," (*all of them Englishmen*)[‡]. The celebrated Prof. John Robison, of Edinburgh, is also as positive. "La machine à feu," says he, "fut, *sans aucun doute*, inventée pour la première fois par le Marquis de Worcester, sous le règne de Charles II*." (See *A System of Mechanical Philosophy*, Vol. II. p. 46.) Then after having refuted, by arguments which I shall examine, the pretensions of the French authors, who *affect* to mix up the name of Papin with the history of the steam-engine, Robison declares "qu'il n'hesite en aucune manière a donner l'honneur de la *premiere* et complete invention au Marquis de Worcester."† (See *A System*, &c., p. 50.) A *savant*, not less illustrious for the extent of his information than for the vastness of his erudition, Dr. Thomas Young, has added his imposing testimony to those I have already cited. According to him, the Marquis of Worcester is the first inventor of the steam-engine,—the first who made use of the pressure of steam as a motor. Again, in the rapid sketch he gives of the improvements that this machine has successively received, none but English mechanicians are introduced. (*Lectures on Natural Philosophy*, Vol. I., pp. 346 and 356.) I could, in addition, mention the able Professor of Mechanics at the Royal Institution, Mr. Millington;—a distinguished member of the new University of London, Mr. Lardner;—the author of an esteemed treatise on Practical Mechanics, Mr. Nicholson, &c. &c.

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[*] "May the best man—win."—Cribb.

[†] ["The steam-engine follows next to the ship, in the scale of inventions; but in an English Cyclopædia it will take the lead, from the circumstance of its being wholly invented, and brought into general use, by our own countrymen."—*Rees' Cyclopædia*, art. *Steam-engine*. Trans.]

[‡] ["The steam-engine is the invention of a few individuals, all of them English."—*Ibid.* Trans.]

Decisions so numerous and so positive, and the deserved reputation of the works from which I have extracted them, did not appear to me to leave the shadow of a doubt. So that when, on the request of the students of the *École Polytechnique*, I attempted, some years ago, to trace a chronological series of the improvements which the steam-engine had received from its origin to the present day, I expected, I frankly acknowledge, to have had to refer to English mechanicians only. This, however, was an error; our neighbours on the other side of the Channel are neither the only, nor even the first, inventors of the steam-engine. This, at least, appears to me to result from a certain number of passages which I now propose to submit to the readers of the *Annuaire*.

I feel sure that I have examined this curious point in the history of the sciences, without prepossession. My quotations and my abstracts shall be correct, and may be depended upon. If the conclusions that I have drawn from them be without foundation, every person may himself correct them, as he will have before him all the elements of the question. Farther, I ought to mention, before concluding this introduction, that there has recently appeared in England itself, a remarkable work, entitled *Descriptive History of the Steam Engine*, by Mr. Robert Stuart, and in which all the attempts that have been made to make use of the vapour of water as a mechanical agent, are appreciated with discernment, and, what is still more rare, with a perfect abnegation of all national prejudice. Except in a very few instances, the opinions of Mr. Stuart on the relative merits of the engineers who have concurred in the crea-

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"* [The steam-engine was, beyond all doubt, first invented by the Marquis of Worcester, during the reign of Charles II." —ROBISON; *System of Mechanical Philosophy*. TRANS.]

† ["We have, therefore, no hesitation in giving the honour of the first and complete invention to the Marquis of Worcester." —*Ibid.* TRANS.]

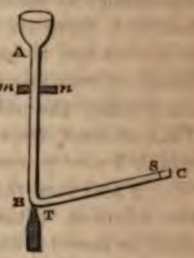
tion of this marvellous machine, are in perfect accordance with those which I have arrived at by a perusal of their original claims. This agreement is too flattering for me not to gladly avail myself of the advantage of it. I shall even add, that if the present notice had not been greatly advanced, when I became acquainted with Mr. Robert Stuart's History, I should probably have been contented with the insertion here of a mere abridgement of his book; in that case the end I proposed to myself would have been as satisfactorily attained.

I hope that my readers will appreciate the motives which have determined me not to follow strictly, a chronological order in all the parts of this Article. I thought there would be greater perspicuity in grouping together passages relating to the various modes, more or less advantageous, which have been successively invented to produce action by steam. Mechanical details, although very important, appeared to me to deserve but the second rank.

A.C. 120. HERON OF ALEXANDRIA*.

WHEN liquids, or gases, or vapours issue from vessels which contain them, under certain conditions which I am about to describe, they become a source of motion that it is necessary fully to appreciate, if it be intended to understand the action of the little apparatus conceived by Heron of Alexandria, and which presents, I think, the first instance of the employment of steam as a motive power.

Fig. 1.



Let us imagine a bent tube, A B C, (*Fig.* 1,) the two branches of which, A B and B C, are at right angles to each other. Let us suppose that the branch A B is vertical, that it passes freely through a fixed ring, *m n*, and that it rests upon a pivot T, so as to turn about itself without hinderance. If, in this state of things, water be poured into the funnel above, we shall have two distinct cases to consider. When the issue of the liquid takes place by the extremity C, in the *direction* B C, the whole of the apparatus will continue at rest. When, on the contrary, the tube B C is stopped at its extremity C, and the liquid issues only by a *lateral* aperture S, in an horizontal direction, the machine will move of itself. It will revolve round A B, so long as the issue continues, but in a direction contrary to that which is taken by the jet. If the water, for instance, spout out from rear to front, the horizontal tube B C will revolve from front to rear, as by a kind of recoil.

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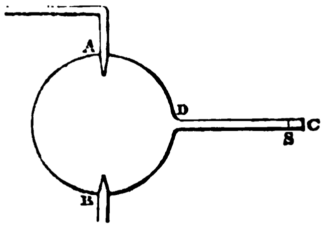
* Heron of Alexandria, called the *Elder*, lived about one hundred and twenty years before our era. The greater part of the numerous works which he composed are lost; three only remain. The reacting machine, (*machine à réaction*,) referred to in the text, may be found described and delineated in the Treatise entitled, *Spiritalia seu Pneumatica.* It has been asserted, that Heron was the first inventor of toothed wheels, but this honour belongs, I conceive, to his master Ctesibius. His *clepsydræ*, and particularly his automatons, excited the admiration of antiquity. The Fountain which bears the name of Heron, has been the subject of various important applications, even in our days; it is used, for instance, as an engine for draining, in the mines of Schemnitz, in Hungary.

All machines in which water has been so employed, bear the name of reacting machines. (*machines à réaction.*)

Gas passed rapidly through the bent tube A B C produces the same effects as water. The tube will be motionless if the gas escape in the direction B C; on the contrary, it will revolve if the issue take place laterally.

These preliminary considerations are sufficient for the comprehension of the mode by which vapour would act in the machine of Heron.

Fig. 2.



Let us suppose that a hollow globe of metal (*Fig.* 2.) that can revolve between two pivots, A and B, is filled with a very elastic vapour, that this vapour can issue from the globe by a projecting tube D C, perpendicular to A B, and in the line of a radius produced. We can already foresee that if the tube D C is open at its extremity, it will have no disposition to revolve, and that the globe will continue at rest,—that if, on the contrary, the issue take place by a lateral aperture S, from rear to front, for instance, the tube will recede, and tend to turn the globe to which it is attached from front to rear. In order to render this rotatory motion continuous, nothing more is necessary to be added to the preceding suppositions, than that one of the two pivots (A, if it be preferred) be hollow,—that one end of it be in communication with the interior of the globe, and the other with a boiler. The vapour given out at S, will thus be continually replaced exactly in proportion to the issue.

In the figure that Heron has given of his little apparatus, two tubes may be seen similar to that I have described. They form opposite prolongations of the same diameter, and their *lateral* apertures are so placed that they both tend to turn the globe in the same direction.

There is also in the *Spiritalia*, the description of a machine exactly resembling the preceding, with the difference only, that a current of heated air supplies the place of the current of vapour.

In short, a certain use of aqueous vapour is found in the apparatus described by Heron, but this vapour operates in it in a manner altogether different from its action in modern machines. Watt, to whom the attempts of the Grecian mechanician were not unknown, was of opinion that nothing useful would ever be drawn from them*. Other persons, if I am correctly informed, augur, on the contrary, so favourably of the effect which it would be possible to obtain by an improvement of the mechanism of Heron, that they have sought to obtain, by a patent, the exclusive right of enjoying it. Time and experience will decide. One thing only can be foreseen, that if by modifications, of which we have not the smallest idea, machines acting by steam and reaction should one day be successful and their history be desired, care must be taken to point out

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* ["Not of a nature to be of any real use."—WATT; *Notes to Robison.* TRANS.]

Heron as their first inventor. As for myself, I might have abstained from mentioning them, since, actually, my duty is only to treat of known machines—of machines employed in manufactories, and these have no resemblance whatever to the revolving globe of the *savant* of Alexandria. Probably, it would have been more to the purpose, to have cited in preference, authors who, like Aristotle and Seneca, attribute earthquakes to the sudden transformation of water into vapour. This transformation being, according to them, produced in the bowels of the earth by subterranean heat, it follows that the grand effects which they are desirous of explaining clearly demonstrate the enormous mechanical power with which vapour appeared to them to be endowed. At all events, I trust I shall be pardoned for this section, when it shall be seen that it affords a natural solution of the important question which was raised not long ago, by the document which I am now about to consider.

1543. BLASCO DE GARAY.

M. DE NAVARRETE published in 1826, in the Astronomical Correspondence of M. le Baron de Zach, the following note, which had been communicated to him by M. Thomas Gonzalez, Director of the Royal Archives of Simancas.

"Blasco de Garay, Captain of the Navy, proposed, A.D. 1543, to the Emperor and King Charles V., a machine to propel vessels and large boats, even during calms, without oars and without sails.

"Notwithstanding the obstacles, and the difficulties that this project was exposed to, the emperor commanded that an experiment should be made of it in the port of Barcelona. This actually took place on the 17th day of June in the said year 1543.

"Garay would not communicate the whole of his discovery. However, on the trial, it was instantly seen that it consisted of a large vessel of boiling water, and of moving wheels attached to each side of the vessel.

"The experiment was made on a vessel of 200 tons, called *The Trinity*, Captain Peter de Scarza, who had arrived from Colibre to discharge corn at Barcelona. By order of Charles V., there were present at this experiment, Don Henry de Toledo, the Governor Don Peter de Cardona, the Treasurer Ravago, the Vice-chancellor and the Intendant, of Catalonia.

"In the reports which were made to the emperor and to the prince, this ingenious invention was generally approved by all persons, particularly on account of the promptitude and the facility with which the vessel could be put about.

"The Treasurer Ravago, an enemy to the project, said that it went two leagues in three hours,—that the machine was too complicated and too costly, and that there was danger of the boiler exploding. The other commissioners asserted that the vessel put about with the same velocity as a galley worked in the usual manner, and that it made a league per hour at the least.

"When the experiment was completed, Garay took away the whole of the machinery with which he had fitted the vessel, he deposited the timbers only in the arsenals of Barcelona, and kept all the rest for himself.

"Notwithstanding the opposition and the contradictions of Ravago, the invention of Garay was approved, and if the expedition with which Charles V. was then engaged had not interfered, it would no doubt have been patronized.

"But withal, the Emperor promoted the author a step, made him a present of 200,000 maravedis, commanded the Treasury to pay him all costs and charges, and in addition bestowed upon him several other favours.

"The above is *derived* from documents and original registers which are preserved in the royal archives of Simancas, among the papers relating to the state of commerce in Catalonia, and those of the Secretaries of War, of Land, and of Sea, of the said year 1543.

"THOMAS GONZALEZ.

"*Simancas*, 17*th August*, 1825."

According to M. de Navarrete, it follows from the note presented above, that *steam-boats are a Spanish invention, and that they have been merely revived in our time.* From it would also follow, that Blasco de Garay must be considered as the true inventor of the steam-engine.

These pretensions appear to me to be of such a nature that they may be both rejected. Generally speaking, the history of the sciences should be based exclusively upon printed documents. Those in manuscript ought to have no value in public estimation, for, in most cases, there is no means of establishing the accuracy of the date which is assigned to them. Extracts from manuscripts are still less admissible. The author of an abstract sometimes has not thoroughly understood the work of which he is giving an account, and he substitutes, even without intending to do so, the ideas of his time,—his own ideas, for the ideas of the writer that he is abridging. I shall grant, nevertheless, that none of these objections are applicable to the case before us,—that the document quoted by M. de Navarrete is really of 1543, and that the extract of M. Gonzalez is faithfully made; but what will be the result? That an attempt was made, in 1543, to propel a vessel by certain machinery, and nothing more. The machine, it may be said, possessed a boiler, therefore it was a steam-engine. This argument is not conclusive. There exists, in fact, in various works, projects of machines in which fire may be seen beneath a boiler filled with water, without the steam performing any part whatever. Such, for example, is the machine of Amontons. Farther, even if it be admitted that steam produced the motion in the machine of Garay, it does not therefore follow necessarily that this machine was new, and that it had any resemblance with those of the present time, for Heron, as has been already seen, described, 1600 years before, the means of producing rotatory motion by the action of vapour. I shall even add, that if the experiment of Garay had taken place, that if his machine was a steam-engine, everything would lead us to believe that he made use of the æolipile of Heron. This apparatus is, in fact, not of very difficult execution, while (it may be boldly asserted) the simplest steam-engine of the present day requires in its construction a precision of workmanship very superior to any which could be obtained in the sixteenth century. Finally, as Garay would not exhibit his machine to any one, not even to the commissioners whom the emperor had appointed, all attempts that might be made after three centuries to determine in what it consisted, would evidently lead to no certain result.

In short, the new document disinterred by M. de Navarrete, must be laid aside: first, because it was not printed in 1543, nor was it later; secondly, because it does not prove that the motor of the vessel at Barcelona was really a steam-engine; thirdly, because, finally, if a steam-engine by Garay ever existed, it was, to all appearance, the reacting æolipile previously described in the works of Heron of Alexandria.

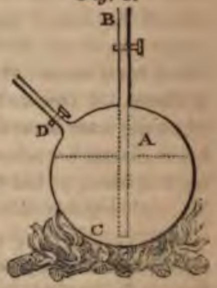
1615. SALOMON DE CAUS*.

SALOMON DE CAUS is the author of a work entitled, *Les Raisons des forces mouvantes, avec diverses machines tant utiles que plaisantes*, &c. This work appeared at Frankfort in 1615. In it, among other ingenious things which several mechanicians of our day have produced as novelties, there will be found a theorem thus expressed, at No. 5: "*Water will ascend* BY THE ASSISTANCE *of Fire higher than its level.*" Caus conveys the proof of this enunciation in the following terms:

"The third mode of elevating water is by the assistance of fire, for which there may be made various machines. I shall here give the demonstration of one of them.

"Let there be a copper ball, marked A (Fig. 3), well soldered all round, to which there shall be a vent, marked D, by which the water is introduced, and also, a tube, marked B C, which shall be soldered on to the top of the ball, and the end, C, shall come near to the bottom, without touching it; when this is done, fill the said ball with water by the vent, then restop it well and place it on the fire. In this case, the heat acting upon the said ball, will elevate all the water by the tube B C."

Fig. 3.



The apparatus of which I have copied the description is a true steam-engine, fit for draining. But probably it might be supposed, if I restricted myself to the preceding passage, that Salomon de Caus was ignorant of the cause of the ascent of the liquid by the tube B C. This cause was perfectly known to him, and I find the proof of it in his Theorem I., p. 2 and 3, in which, in relation to a very similar experiment, he says, that "the violence of the vapour (produced by the action of the fire) which causes the water to ascend, proceeds from the said water, which vapour will issue after the water shall have issued by the cock with great violence."

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* It is singular, and very deserving of observation, that a man whom posterity will perhaps consider the first inventor of the steam-engine, should not be noticed in the history of the mathematics by Montucla, except for his Treatise on Perspective, and then the reference is despatched in five words. He has also scarcely obtained the honour of an article of a few lines in the voluminous biographical dictionaries of our days. The *Biographie Universelle* places his birth and death in Normandy, and says that he lived some time in England, attached to the Prince of Wales. In the *Raisons des forces mouvantes*, Salomon de Caus takes, himself, the title of *Ingénieur et d'Architecte de S. Altesse Palatine Electorale.* This work was composed, I am of opinion, at *Heidelberg;* it was printed at *Frankfort.* These three circumstances have induced some persons to suppose that Caus was a German. But let us first observe, that it would be scarcely probable that a German would have written in French in his own country. To this let it be added, that in the Dedication to the most Christian King (Louis XIII.), the following formula precedes the signature:—*De votre Majesté, le très obéissant* SUBJECT;—that, finally, there is found in the license that which cuts off all doubt—" Nostre bien aimé Salomon de Caus, Maistre Ingénieur, *estant de présent* au service de nostre cher et bien aimé cousin le Prince Electeur Palatin, nous a fait dire, &c. . . . désirant gratifier le dict de Caus, comme estant *Nostre subject,*" &c. *Ergo,*—Salomon de Caus was a Frenchman.

1629. BRANCA.

BRANCA is the author of a compilation, entitled *La Machina del sig G. Branca: Roma*, 1629. This work contains the description of all the machines within the author's knowledge. In this number may be observed an æolipile placed on a brasier, and so arranged that the current of vapour which issues by a tube, strikes upon the sails or the paddles of a small horizontal wheel, and turns it. The current from the pipe of a common bellows will evidently produce the same effect.

I have hitherto not been able to conjecture by what anology there can be detected in this æolipile the first germ of the steam-engines which are now in use. At all events, and I shall confine myself to the remark, the collection of Branca is very much later than the two first editions of the work of Salomon de Caus.

1663. MARQUIS OF WORCESTER[*].

THE *Scantling of One Hundred Inventions*, by the Marquis of Worcester, appeared in 1663, during the reign of Charles II. This book is more generally known under the title of *Century of Inventions*. The machine which English authors consider as *the first steam-engine*, is described in these terms (it is the 68th invention):

[†] "J'ai inventé un moyen admirable et très puissant d'élever l'eau

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[*] Edward Somerset, Marquis of Worcester, whom the English consider the true inventor of the steam-engine, lived under the reign of the latter Stuarts. Thrown among all the intrigues of this period, he experienced numerous vicissitudes. At first Worcester lost his immense fortune; he went over to Ireland only to be there imprisoned; he escaped, reached France, returned to London by command of Charles II., was detected, and shut up in the Tower, whence he was released only by the Restoration. Tradition reports that the notions of Worcester on the use that it might be possible to make of the power which aqueous vapour possesses, were suggested during his latter detention, by the sudden elevation of the cover of the vessel in which his food was preparing. If this anecdote were true, it would be very honourable to the inventive mind of the prisoner; but at the same time, it would show his small stock of information, for it would be necessary to admit that he was not aware of the work of Salomon de Caus. Now, it is known that a second edition of this book had appeared in France during the time that Worcester resided there.

[†] [" No. LXVIII. (A Fire Waterwork.)—An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be, as the philosopher calleth it, *infra sphæram activitatis*, which is but at such a distance. But this way hath no bounder, if the vessels be strong enough; for I have taken a piece of a whole cannon, whereof the end was burst, and filled it three quarters full, stopping and screwing up the broken end, as also the touchhole, and making a constant fire under it. Within 24 hours it burst, and made a great crack; so that, having found a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other, have seen the water run like a constant fountain stream, 40 feet high. One vessel of water, rarefied by fire, driveth up 40 of cold water; and a man that tends the cock is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim between the

à l'aide du feu, non par aspiration, car alors on serait renfermé, comme disent les philosophes, *intra sphæram activitatis*, l'aspiration ne s'opérant que pour certaines distances; mais mon moyen n'a pas de limite, si le vase a une force suffisante. Je pris en effet un canon entier dont la bouche avait éclaté, et l'ayant rempli d'eau aux trois quarts, je fermai par des vis l'extrémité rompue et la lumière; j'entretins ensuite dessous un feu constant et au bout de vingt-quatre heures, le canon se brisa en faisant un grand bruit. Ayant alors trouvé le moyen de former des vases de telles manières qu'ils sont consolidés par la force intérieure[*], et qui se remplissent l'un après l'autre, jai vu l'eau couler d'une manière continue comme celle d'une fontaine, à la hauteur de quarante pieds. Un vase d'eau raréfiée par l'action du feu élevait quarante vases d'eau froide. L'ouvrier que surveille la manœuvre n'a que deux robinets à ouvrir, de telle sorte qu'aù moment où l'un des deux vases est épuisé, il se remplit d'eau froide pendant que l'autre commence à agir, et ainsi successivement. Le feu est entretenu dans un degré constant d'activité par les soins du même ouvrier; il a pour cela tout le temps nécessaire durant les intervalles que lui lasse la manœuvre des robinets."

The reader now knows all that the Marquis of Worcester has ever written upon the steam-engine. This is the only ground upon which Mr. Partington, of the London Institution, in his new edition (1825) of the *Century of Inventions*, reposes his decision, together with all his countrymen, that "Worcester est le premier homme qui ait découvert un moyen d'appliquer la vapeur comme agent mécanique; invention qui seule," he adds, "suffirait pour immortaliser l'âge dans lequel cet homme vivait [†]."

Let us, in our turn, examine this passage, so frequently quoted, and let us see, without partiality, what it really contains at bottom.

I see in it, first, an experiment adapted to show that water reduced to vapour can, at length, burst through the sides of the vessels which enclose it. This experiment was already known in 1605, for Flurence Rivault expressly says that æolipiles explode with noise when the escape of the vapour is prevented. He adds, too, *The effect of the rarefaction*

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necessity of turning the cocks."—*Century of Inventions.* Partington's Edition, 1825. TRANS.]

[*] This passage has been almost always translated differently, "Ayant découvert;" so they make Worcester say, "le moyen de fortifier les vaisseaux intérieurement," &c. &c. The phrase, I must admit, is far more rational than my version, but this is almost an argument against its fidelity, so chimerical and extravagant are, in general, the projects of Worcester. Farther, the text of the original says, "Having a way to make my vessels so that they are *strengthened by the* FORCE *within them*," &c. &c. It appears to me, that *force within them* cannot designate any means of interior consolidation. If I have comprehended these words correctly, Worcester, in order to answer an objection which he foresaw, has thought proper to assert that his new boilers would never burst; and in fact he would have accomplished this object, if, as he says, they became stronger in proportion to the intensity with which the vapour pressed them from within to without. This circumstance will give additional weight to the opinion of those who think that Worcester never made a trial of his machine, but I am desirous of remarking that all this is of no importance to the question of priority which we must discuss here.

[†] ["The man who first discovered a mode of applying steam as a mechanical agent,—an invention alone sufficient to immortalize the age in which he lived."—*Century of Inventions*, Partington's Edition. 1825. TRANS.]

of the water is sufficient to alarm the most courageous men[*]—(*Eléments d'Artillerie, p.* 128. Paris, 1605.)

I see in it, farther, the notion of raising water by the elastic force of vapour. This notion belongs to Salomon de Caus, who published it 48 years before the English author.

I find in it, finally, the description of an apparatus adapted to produce this effect; but who did not know that the metallic ball of Salomon de Caus would also raise water to any height whatever, if we suppose the sides to be sufficiently strong, and the heat very intense? Perhaps it may be said that the machine of the Marquis of Worcester is the preferable one. I can grant this, and no consequence will follow; for the question is not, at the present moment, to ascertain which engineer conceived the better steam-engine, but simply who was the first to take advantage of the elastic force of vapour in order to raise a weight, or to produce motion. Farther, before we can compare the project of the Marquis of Worcester with other projects, we must know accurately in what the former consisted. This problem has not hitherto been solved, for the very simple reason that the description of the 68th invention of the English nobleman is totally deficient in clearness. No person, in the present day, would be embarrassed, if he were required to construct a machine for draining in which water should be lifted by the action of vapour; but when the question is to reproduce that of the Marquis of Worcester, we must be bound to do what the author describes, and nothing more.

Mr. Stuart, submitting to these two conditions, has found that an approximation, the nearest possible, may be made to the description of his countryman, by grouping together two of the machines of Salomon de Caus, so as to produce, by their alternate play, a continuous flow. The other solutions that have been hitherto given, of the same problem, as that of Millington for example, are evidently inadmissible.

When MM. Thomas Young, Robison, Partington, Tredgold, Millington, Nicholson, Lardner, &c., held up to view the Marquis of Worcester as the inventor of the steam-engine, the work of Salomon de Caus was, doubtless, unknown to them. Since it is now established, without contradiction, that the first idea of raising weights by the assistance of the elastic force of vapour, belongs to the French author; that if even the machine of his competitor did ever exist, it was, according to all appearance, the apparatus described nearly half a century before, in the

[*] I borrow this quotation from one of the curious historical articles, so rich in erudition, that M de Montgéry has published on the machines in which fire is, in any manner, employed, and I substitute it for the following passage from Salomon de Caus, which I had at first inserted in the text. This passage did not appear until ten years after, that is to say, in 1615, but nevertheless nearly 50 years before the *Century of Inventions.* "The violence will be great when the water exhales into air by means of the fire, and the said air is enclosed. As for example: let there be a ball of copper, of a foot or two in diameter, and of an inch thick, the which shall be filled with water by a small hole, the which shall be stopped strongly with a nail, so that the water cannot get out; it is certain, that if the said ball be put on a large fire, so that it become very hot, there will be a compression so violent that the ball will explode in pieces with a noise resembling a petard."—(*Les Raisons des forces mouvantes*, liv. 1. feuille 1, verso.)

work entitled *Raisons des forces mouvantes*, we must now believe that, in future, the modest name of Salomon de Caus will constantly be inscribed wherever, up to the present time, that of the Marquis of Worcester has figured in the first rank.

1683. SIR SAMUEL MORELAND[*].

IF it was my intention, in this notice, to speak of those persons only whose labours have really contributed either to the production, or to the improvement, of steam-engines, the name of the Chevalier Moreland would not appear in it; but this name being mentioned by nearly the whole of the authors who have treated of steam-engines in England, I have felt obliged to mention it myself, if it were only to justify the opinion I have advanced.

There is, in the British Museum, a very beautiful *manuscript* of the Chevalier Moreland, entitled "*Elevation des Eaux par toutes sortes de machines, réduite à la mesure, au poids et à la balance*, présentée à Sa Majesté très chrétienne par le chevalier Moreland, gentilhomme ordinaire de la chambre privée et maitre des mécaniques du roi de la Grande-Bretagne[†]."

In this manuscript of 38 pages, the article relating to the steam-engine occupies four only, and is distinguished from the rest by a particular title. The following passage is that by which they justify themselves in England, for attributing to Moreland a certain share in the production of the steam-engine:

"Water being evaporated by the power of fire, its vapours instantly require a larger space (about 2000 times) than the water occupied before; and rather than be always imprisoned, would burst a piece of cannon. But being well governed by the laws of statics, and reduced by science to measure, weight, and equilibrium, then they carry peaceably their burdens (like good horses), and thus would be of great use to the human race, particularly for the raising of water, according to the following table, which marks the number of pounds which can be lifted 1800 times per hour, six inches high, by cylinders half-filled with water, as well as the several diameters and depths of the said cylinders."

If the work of Moreland had preceded those of Salomon de Caus, or of Worcester, the passage above quoted would constitute a real title. In 1683, that is to say, 68 years after the publication of the *Raisons des*

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[*] Sir Samuel Moreland[1], like Worcester, took an active part in the events of the civil wars. Cromwell employed him in several diplomatic missions. His countrymen assert that he was simultaneously secretary to Thurloe, and an accredited spy of the King. At the Restoration, Charles created him a baronet. Moreland studied several questions in acoustics; among others that of the best form to be given to the speaking-trumpet. He died at Hammersmith, in the month of January, 1696, after having had the singular notion of burying six feet deep a large collection of musical works which he possessed, as a mark of repentance for his past life.

[1] [He writes himself "Morland." TRANS.]

[†] There exists a work of Moreland, *printed* at Paris in 1685, and which has almost exactly the same title as the manuscript in the *British Museum*. The chapter relating to vapour is not found in it. The author, in enumerating in his preface all the kinds of motors that the mechanician puts in action, merely mentions those of gunpowder and of the vapour of water, without making any remark upon the subject which would indicate whether he considered himself as an inventor, or merely spoke a thing already proposed by another.

forces mouvantes, and 20 years after the date of the patent of Worcester, the project of Moreland could only be considered as a plagiarism. Let us, nevertheless, say, to the honour of this mechanician, that the numbers which he gives to express the relative volumes of water and of an equal weight of vapour, are less remote from the truth than could have been expected from experiments made in 1682.

1690 & 1695.—DENIS PAPIN*.

Fig. 4.

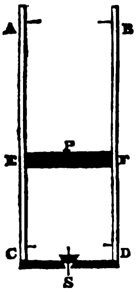
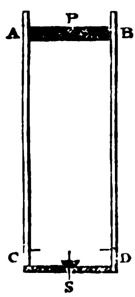


Fig. 5.



SUPPOSE a broad vertical cylinder, A B C D, Fig. 4, entirely open at its upper part, and resting on a metallic base provided with a valve, S, which opens upwards at pleasure. Place in the middle of this cylinder a moveable piston, P, which closes very accurately the aperture of the cylinder. The atmosphere will press with all its weight on the superior face of this piston;—it will push it downwards. If the valve S be open, the portion of the atmosphere which fills the space D C E F will tend, on the contrary, by its reaction, to elevate the piston. This second force will be equal to the first, because, in a gas, as in a fluid, the pressure on every point is the same in every direction. The piston, thus influenced by two forces which are in equilibrium, will, nevertheless, descend, but only by the effect of its own weight. The smallest effort, therefore, which should be superior to this same weight, would be sufficient to elevate the piston to the summit of the cylinder, and to maintain it there.

Suppose, in fact, that the piston has been conducted to the superior extremity of its course, as is represented in fig. 5, and let us seek to make it forcibly descend. A very efficacious means would be to shut the valve S, and then, if it were possible, to annihilate suddenly and completely the portion of atmospheric air which fills the space A B C D, in the body of the pump. In this case the piston would receive no other action than that of the exterior atmosphere with which it is loaded. This action would operate downwards upon the superior surface, and would be measured by the weight of a column of water of 10 mètres (about 33 Eng. ft.) in height, and the base of which would be equal to that of the body of the pump, or, which comes to the same, the weight of a column of mercury of an equal base and only 76 centimètres (about 30 Eng. in.) high, for such is the weight of the atmosphere.

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[*] Denis Papin was born at Blois. His youth was devoted to the study of medicine, and he took his degrees at Paris; afterwards he visited England, where Boyle, who had admitted him to some of his experiments, procured his nomination as a member of the Royal Society, in 1681. Obliged to leave his country by the revocation of the edict of Nantes, Papin took refuge in Germany with the Landgrave of Hesse, and discharged, in a distinguished manner, for several years, the functions of Professor of Mathematics at the University of Marbourg; he died in 1710. It may be considered singular that the *Académie des Sciences* of Paris did not make Papin one of its associates, when it is known that as early as 1690 he had published a memoir in which is found, as we shall immediately see, the clearest and most methodical description of the steam-engine, known in the present day as the *atmospheric engine*, and even that used in *steam-boats*. The man of genius is always neglected, if he is in advance of his age, let it be in whatever direction it may.

The piston would in this case necessarily descend, and could even pull up in its course a weight equal to that of the column of water or that of the mercury, which I have just mentioned.

Following always the same hypothesis,—admit that at the moment when the descending movement is entirely completed, the valve is opened. The atmosphere will then act beneath, and counterbalance the action of the atmosphere above. A very little effort would now be sufficient to carry back the piston to the summit of the body of the pump, and replace all the parts of the apparatus in their initial position. A second annihilation of the internal atmosphere would again sink the piston, and so on.

In short, in this apparatus, a small expenditure of power is sufficient to elevate the piston, at the same time its descending movement can produce the greatest effects. If the end of a cord be attached to the centre of the piston, and its other extremity be carried over a pulley, we can, at each descending movement, lift a very great weight—equal in quantity to the height of the body of the pump. With a cylinder of two mètres (about 6 feet 7 in. Eng.) in diameter, the weight lifted at each descending oscillation of the piston would be 31,000 kilogrammes (about 30½ Eng. tons.)

The idea of the machine of which I have just spoken belongs to Papin. It is described distinctly in the *Acta Eruditorum Lipsiæ* for the year 1688, p. 644, and afterwards, with some new developements, in a letter to Count William Maurice (*see* the work, printed at Cassel, in 1695, and entitled *Recueil de diverses pièces touchant quelques nouvelles machines*, p. 38 *et seq.*) There now remains to be explained the means by which Papin proposed to annihilate, at the proper moment, the stratum of atmospheric air, which, lying under the piston, would obstruct the descending movement; or, which comes to the same thing, there is still to be described how he could, at will, produce a vacuum in the lower part of the pump.

This *physicien* had for some time the intention of using, for this purpose, a water-wheel, which would have worked the pistons of a common suction-pump. When the stream of water destined to move this wheel was situated very far from the machine, he would have connected it with the pump by the inter-means of a continuous metallic tube, similar to those of the gas-works of our day; this was, he said, *a means of transporting river-power to a great distance.*

In 1687, the machine was, in this state, presented to the Royal Society of London, where difficulties arose, which Papin mentions, without saying in what they consisted. (See *Recueil*, p. 41.) Previous to this, he had attempted to produce the vacuum under the piston by means of gunpowder; but "notwithstanding all the precautions that were taken," says he, "there always remained in the tube, about one-fifth part of the air which it ordinarily contained; this caused two different inconveniences: one, that about a moiety of the power that ought to be obtained was lost, so that 150 lbs. only could be raised to a foot in height, instead of 300 lbs., which would have been lifted if the tube had been perfectly exhausted. The other, that in the degree that the piston descended, did the depressing force diminish more and more;" &c. (*Recueil*, &c. p. 52.)

"I therefore set myself," he adds, "to accomplish the same end in another way: *and as water has the property, being changed by fire into vapours, to spring as air, and afterwards to be so completely re-condensed* BY COLD, *that there does not remain in it the slightest appearance of this elastic power, I therefore thought it would not be difficult to construct machines, in which by means of a moderate fire, and at small cost, water would produce the perfect vacuum which had been so unsuccessfully sought by means of gunpowder.*"

This important passage is found at p. 53 of the *Recueil*, printed at Cassel, in 1695, as an extract from the *Acta Eruditorum Lipsiæ*, for the month of August, 1690. It is followed by the description of the little apparatus which Papin used in the attempt to realize his invention. The body of the pump was but 2½ inches in diameter, and did not weigh 5 ounces. At each oscillation it lifted 60 lbs. to a height equal to the dimensions of the descending course of the piston. The vapour disappeared so completely when the fire was removed, that the piston to which this vapour had communicated the ascending movement "redescended to the bottom, in such a manner that there was no reason to suppose that there was any air to press it beneath, and oppose its descent." (*Recueil*, p. 55.)

The water which furnished the vapour, in these first attempts, was not contained in a separate boiler, but was placed in the body of the pump itself upon the metallic plate which closed it at bottom. It was this plate that Papin heated directly to transform the water into vapour; it was the same plate that he cooled by removing the fire when he wished to produce condensation. He reports, that with a moderate fire he required but a minute, in the experiments of 1690, "to drive the piston in this manner to the summit of its tube." (*Recueil*, p. 55.) But in subsequent attempts he "exhausted the tubes in a quarter of a minute." (*Recueil*, p. 61.)

Finally, he himself declares that starting always from the principle of the condensation of vapour by cold, the end which he proposed might be attained "by various constructions easy to be imagined." (See *Receuil*, p. 53.)

The machines of Salomon de Caus, and of the Marquis of Worcester, were simple draining apparatus. Their authors proposed them only as means of raising water. This was also the principal object of Papin in his atmospheric-pressure engine, but at the same time he saw perfectly well, that the alternate movement of the piston in the body of the pump was capable of other applications, and could become a universal motor.

In fact, there may be found, at pp. 58 and 59 of the *Recueil*, and even so early as in the *Acta Eruditorum Lipsiæ*, of 1690, a method adapted to change this alternating movement into one of rotation. I do not insist longer on this point, in this place, because we shall have to consider it farther on, under the head of steam-boats, and I shall conclude this section on Papin, by presenting to the reader the several consequences which appear to me to flow from the extracts which he has just read.—

Papin conceived the first piston steam-engine.

Papin was the first to see that aqueous vapour furnished a simple means of producing rapidly the vacuum in the space of the body of the pump.

Papin is the first who thought of combining in the same steam-engine, the action of the elastic force of vapour, with the property which this vapour possesses—and which he remarked—of condensing by cooling*.

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* M M. Stuart and Partington have explicitly acknowledged all these claims of Papin to the grateful recollection of mechanicians; but to compensate this, those persons who will read Dr. Robison's History of Steam-engines (see the last Edition, with notes by Watt,) will there find, p. 49, that the *premier* memoir (*First publication*) of Papin on steam-engines, is that of 1707[1]; that this mechanician did not propose to employ a true piston, but a mere float—that he never, and this is the most important point, dreamt of producing the downward movement of a piston by the condensation of vapour. These decisions are also contained in Rees's Encyclopædia, art. *Steam-engine*; the author of this article had read in the *Acta Eruditorum Lipsiæ*, the description of the machines in which Papin had attempted to produce a vacuum by the means of gunpowder, for he quotes them; but by an inexplicable fatality, the memoir inserted in the same *Acta*, in which Papin substitutes the vapour of water for gunpowder, did not attract his attention, since he declares that the machines of the French mechanician were never *intended to be worked by steam*. Mr. Millington is hardly more favourable to our compatriot, whose ideas, he says, upon the means of producing a powerful motor by the assistance of vapour, are all subsequent to the patent of Savery, (p. 255)[2]; (the patent of Savery was in 1698.)

Mr. Lardner likewise asserts, in the Lectures which he has recently published, "que les Français appuient leur *prètentions* à l'invention de la machine à vapeur, sur un ouvrage de Papin qui n'a paru qu'en 1707, neuf ans après la date du brevet de Savery. Cette remarque, ajoute-t-il, tranche tout-a-fait le question : Papin n' a droit à aucun partage dans l'invention de la machine à vapeur[3]. (See *Leçons sur la Machine à vapeur*, pp. 96, 97, and 101, de l'édition française.)

Is it not really curious, that the greater part of the English authors thus persist in citing one work only of Papin, that of 1707—that they will not take any notice of the more voluminous work from which I have borrowed literally, several passages, and of which there appeared two editions in the same year, 1695, the one at Cassel, in French, the other at Marbourg, in Latin—that all the memoirs by this author, inserted in the *Acta Eruditorum Lipsiæ* seem to them never to have existed! I will admit, if it be wished, that there does not exist a piston properly so called, in the *machine d'épuisement* of 1707; that the condensation of vapour actually performs no part in it; that in every case, this machine is posterior to the patent of Captain Savery; without it being possible to draw any conclusion from these admissions, because it is not the work of 1707 that we cite, but really a *Recueil* of 1695, but really the *Acta Eruditorum Lipsiæ* of the year 1690. Bossut, in his Hydrodynamics, takes as his authority, the work of 1695, for giving to Papin an important share in the invention of the steam-engine; Robison replies that this work does not exist! (*The fact is, that Papin's first publication was in 1707.*) I could conceive his declaring that he had not seen it; but this absolute denial, opposed to the positive assertions of Bossut, was the more singular, for Papin's book is

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[1] ["Now the fact is, that Papin's first publication was in 1707, and his piston is nothing more than a floater on the surface of the water, to prevent the waste of steam by condensation, and the return of the piston is not produced, as in the steam-engine, by the condensation of the steam, but by admitting the air, and a column of water, to press it back into its place."—ROBISON; *System of Mechanical Philosophy*. TRANS.]

[2] ["It was not until after Savery had obtained his patent, that the attention of Papin was at all directed to the means of obtaining a moving power by steam."—MILLINGTON; *Nat. and Exp. Philosophy*.]

[3] "In 1707, Papin, a native of France, and Professor of Mathematics at *Marpurg*, published a work, entitled *A New Method of raising Water by Fire*, in which a steam-engine is described, which would scarcely merit notice here, were it not that it forms the ground on whch the French claim the invention of the steam-engine. The publication of Papin's book was nine years after Savery's patent, with which he acknowledges himself acquainted, and two years after Newcomen's."

"In every point of view it is inferior to the engines of Savery and Newcomen : and the date of its first publication puts an end to all question respecting the right of Papin to any share in the invention of the steam-engine." —LARDNER;—Lectures on the *Steam-engine*, Lond. 1828.

1698. CAPTAIN SAVERY.

WE have no proof, whatever, that Salomon de Caus ever constructed his steam-engine. I may also say the same of the Marquis of Worcester*. The machine of Papin in which the action of vapour and its condensation are successively in action, was executed on a small scale only, and merely with the view to establish experimentally the correctness of the principle on which it was based†. Thus, although, properly speaking, there was nothing very new in the steam-engines of Savery, they could not, without great injustice, be passed over without notice, as they really were the first that were applied. Farther, I do not think it my duty to introduce here the delineation; the reader will be able without this assistance to obtain a correct idea, if he will refer to that of Salomon de Caus and pay some attention to the following considerations.

According to the project of Caus, the acting vapour would be engendered in the vessel which contained the water to be raised, and at the expense of the same water. In the machine of Savery there are two distinct vessels; the one contains the water; the other, that may be called (*la chaudière*) the boiler, contains the vapour. This vapour, when considered sufficiently abundant, is conveyed to the upper part of the water-vessel by a communicating tube, opening at pleasure by means of a cock. It acts downwards on the surface of the fluid, and forces it into an ascending vertical tube, the lower aperture of which must always be situated below this surface, for, if it be not so, the vapour itself would escape. As far as this point the difference between the two machines is trifling: let us go on with the comparison.

In the engine of Salomon de Caus, as soon as the pressure of the vapour has produced its effect, an assistant replaces the expelled water, by means of an aperture situated in the upper part of the metallic sphere, and which is opened or closed at pleasure. Nothing more remains to be

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not very scarce in England, for at any rate the *Acta Eruditorum Lipsiæ*, which contain the substance, may be found in the principal libraries, and finally, this work whose existence is denied by the celebrated Professor of Edinburgh was announced and analyzed, in March 1697, in the *Philosophical Transactions*, a year before there was any question about the machine of Savery. In the analysis of the *Philosophical Transactions*,—and this observation should not be forgotten—there is also given, literally, the passage from Papin's work which relates to the use of vapour as a means of producing the vacuum in the body of the pump. (See *Trans.* vol. xix. p. 483.)

* The privilege solicited by the Marquis of Worcester was granted to him, according to Walpole, *on the simple assurance* which he gave to the Commissioners appointed for the purpose, that he had invented a machine which moved by the action of vapour. If the machine had been *actually constructed*, the remark relative to the declaration, as Mr. Stuart observes, would not have been necessary. I am not ignorant, that on the contrary, it has been asserted, that the Bill solicited by Worcester was finally subjected to long and minute examination, but to neutralize the evidence of Walpole, it must be proved that the Parliamentary Commissioners had seen a machine in action, or at least a model, and nobody up to the present hour has pretended to do this.

† The Count de Sintzendorff, proprietor of several mines in Bohemia which were overflowed, invited Papin to visit and drain them, with his engine; but the calamitous circumstances in which Germany was then placed, did not permit him to remove. "I could wish extremely," said he, "to render my very humble services to Your Excellence, was it not that the country which we see ruined in our neighbourhood, and the uncertainty of military events, warn me that I ought not to abandon my family so long in times like these." (*Recueil de diverses pièces, &c.*, p. 49.)

done than keeping up the fire. In the machine of Savery, it is not an assistant, but the atmospheric pressure, which carries the water into the water-vessel. The vapour, during the first period of its action, forces before it the water that this vessel contains, and is, itself, substituted for this water. Now, vapour, whatever may be its primitive elastic force, is in greater part precipitated, if its temperature be much reduced. It is sufficient, and such is, in fact, the process adopted by Savery, to throw cold water upon the sides of the vessel whose interior is filled with steam. After this operation, the atmospheric pressure will overcome, with great ease, the scarcely sensible elasticity of the vapour which the cooling has not annihilated, and if the vessel be in communication by a tube with a sheet of water, whose surface is not more than 25 or 30 feet lower, it will be re-filled by suction. If I add that, in order to avoid intermission in the flow, Savery employed a third vessel, which was filled with water during the emptying of the second, and reciprocally,—and that the second and the third vessels were *the one after the other* in communication with the boiler, by means of an appropriate system of tubes and cocks, I shall have indicated all that was essential in the machine of this engineer.

The engine of Salomon de Caus has been a subject of reproach, inasmuch as it lifts *hot* water only. This reproach, it must be acknowledged, has some weight in economical considerations, but it also applies, to a certain extent, to the engine of Savery. In this, in fact, the vapour of the boiler, before it acts upon the water-surface in the second, or in the third vessel, will, if nothing intervene, condense upon it in great quantities. Its elasticity does not become efficacious until the water has acquired an elevated temperature. When, therefore, the water begins to ascend, it is warm. Robison says that he ascertained, experimentally, that in making use of vapour in Savery's mode, there was at least $\frac{11}{12}$ths condensed, either by the sides of the second or of the third vessel, or by the water which they contained, even when this water yielded to the smallest pressure. In an analogous machine, for the purpose of avoiding the enormous loss of vapour, of which I have just spoken, Papin conceived, in 1707, the idea of covering the water with a float*. This contrivance was not adopted; less, I think, from difficulties of execution, than from the important defects which are inseparable from this class of machines. In order to raise water to the height of 65 mètres (71 Eng. yards), for example, Savery was compelled to raise the pressure of his boiler to six atmospheres; this produced continual derangements in the joints, the melting of the solderings, and even dangerous explosions. Thus, notwithstanding the title of his work, the engines of this engineer were not usefully employed in mines. They were only used to distribute water in various parts of mansions and pleasure-houses, in parks, and in gardens: anywhere, in a word, where the difference of level to be overcome did not exceed about forty feet. By the assistance of the engine proposed by Papin, there is, on the contrary, no height to which water cannot be carried, even should vapour of very feeble tension be employed: all that is necessary in such a case is, to give to the body of the pump a diameter sufficiently great.

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* Mr. Robert Stuart believes that, by the introduction of a float into the body of the pump, Papin's object was not to prevent the condensation of the vapour [1]. (See *Descriptive History*, 2nd edit., p. 52.) Papin, however, expresses himself very clearly upon this subject; and we shall see, even by the passage that I find at page 26 of the work of 1707, in what manner this defect struck him.

"I observe that the hot vapours which enter the pump to drive out the water, meet in the engine (that of Savery) the cold water which condenses them, and causes the loss of the greater part of their power. It is not until the water is heated, that it can be expelled; therefore, to heat the water, great consumption of vapour is necessary; the water must be often renewed in the boiler, and much time and wood is required to heat it again. But by the means of our piston (a double-bottomed float) the vapours meet only with the same surface of this metal, which soon acquires so great a heat, that the vapours lose none, or very little, of their power in striking upon it."

[1] ["It does not, however, appear that Papin adopted the floater to prevent the condensation of steam, by keeping it from coming into contact with water, for it was practically impossible to produce this contact in his apparatus."—STUART; *Descriptive History of the Steam-engine*. TRANS.]

In short, Savery attempted to use the elastic force of vapour to force up the water in a vertical tube; but Salomon de Caus had done it, precisely in the same way, eighty-three years before. Savery filled by suction the vessels in which the vapour afterwards acted; but, in 1698, suction was not a novel principle, since the *horror of a vacuum* had been very anciently invented to explain it, and, besides, applications of it, exactly similar to those of the English mechanician are contained in the *Raisons des forces mouvantes, feuille* 19, *verso.* Suction, too, contributed very little to the value of the engine, for it merely added about thirty feet to the height to which the fluid could have been elevated without it.

Savery, finally, produced the vacuum which induced the suction, *by the cooling of vapour.* Here is an important point, but—Papin had published the method a long time previous. The patent granted to Savery is dated the 25th of July, 1698; the experiments with his machine before the Royal Society were made in the month of June, 1699; the first edition of the *Miner's Friend* bears the date of 1702: therefore the priority of the titles of Papin would have the advantage of three years, even in the case, when laying aside the *Acta Eruditorum Lipsiæ*, we should go no further than the *Recueil*, in which are collected several memoirs by this mechanician, for this work was published in 1695. What remains, therefore, to Savery? The honour to have first *executed*, on rather a large scale, a steam-engine for draining, and, if it be desired,—that of having obtained the condensation of vapour by cooling, through the means of sprinkling the *external sides of the metallic vessel* which contained the vapour, with cold water. In describing, for the first time, this ingenious means of producing a vacuum, Papin, in fact, is not explicit on the *different constructions easy to imagine* (these are his expressions) *that may be employed* to obtain this object. During his *experiments* with a little cylinder, he was contented, as has been seen, to take away the fire.

[*To be continued.*]

SIMULTANEOUS METEOROLOGY. No. III.

It is earnestly to be hoped that the periodical Hourly Meteorological Observations, suggested by Sir John Herschel, may be universally made, and that with the most scrupulous fidelity and accuracy. An abundant harvest of precious facts will soon present itself to students of meteorology.

One instance of the innumerable and deeply-interesting comparisons, which may be made by means of these series, has been furnished us by a correspondent.

The Tables annexed have been drawn up from observations which were made at the March-Equinox of this year, and since published in this or other scientific journals. They contain the more remarkable meteorological circumstances which occurred at two places in different quarters of the world, lying on different sides of the equator, and about six thousand miles asunder; viz., Blackheath in Europe, and Feldhausen in Africa. They also exhibit the atmospheric phenomena which existed at the same instant of time in these two widely-distant spots. When this shall be done in every region of the earth and sea, meteorology will possess a million-eyed Argus, whose watchings will, four times every year, detect and expose the similitudes or differences in the physical condition of the atmosphere of a world.

We abstain from indicating results, and pursuing reflections, which an examination of these tables naturally elicits and suggests, because, at present, the meteorological reports do not all of them possess sufficient data for a satisfactory comparison, and have not all been subjected to those processes of reduction which are necessary for such a purpose. In the present case, for example, the European observations of the barometer are not reduced to 32° Fahr., as are the African ones; nor is the difference of level of the two stations given, &c. Still they are sufficient to show that, at the period in question, the pressure at the two places was almost identically the same,—that the temperature was extremely different,—that its range was remarkably greater at Feldhausen than at Blackheath, &c.

No. I.

TABLE of the maximum and minimum Pressure and Temperature of the Atmosphere during the Hourly Series of Observations for the March-Equinox, 1837, made by Mr. J. H. Belville, at Blackheath Road, near Greenwich; to which are annexed the Pressure and Temperature at the same instants of time at Feldhausen, near Wynberg, Cape of Good Hope.

BAROMETER.

Blackheath Road. Feldhausen.

	Time.		Corresponding Instant.			Diff. at the same Inst.	Place where the mer. col. was highest.
in.	h. m.				in.	in.	
Max. 29·971	VI. 0 A.M.	21 Mar.	VII. 13½ A.M.	21 Mar.	29·724	0·247	Blackheath Road.
Min. 29·796	IV. 0 A.M	22 —	V. 13½ A.M.	22 —	29·792	0·004	Blackheath Road.
	V. 0 A.M.	22 —	VI. 13½ A.M.	22 —	29·802	0·006	Feldhausen.
Diff. 0·175							

THERMOMETER.

Blackheath Road. **Feldhausen.**

		Time.		Corresponding Instant.			Diff. at the same Inst.	Place where the mer. col. was highest.
	°	h. m.				°	°	
Interior.		XI. 0 P.M.	21 Mar.	O. 13¾ A.M.	22 Mar.	70·0	27.0	Feldhausen.
	Max. 43·0	XII. 0 P.M.		I. 13¾ A.M.	22 —	70·0	27·0	Feldhausen.
		I. 0 A.M.	22 Mar.	II. 13¾ A.M.	22 —	70·0	27·0	Feldhausen.
		II. 0 A.M.		III. 13¾ A.M.	22 —	70.2	26·8	Feldhausen.
		III. 0 A.M.		IV. 13¾ A.M.	22 —	70·2	26·8	Feldhausen.
		IV. 0 A.M.		V. 13¾ A.M.	22 —	70·0	27·0	Feldhausen.
		I. 0 P.M.		II. 13¾ P.M.	22 —	70·0	27·0	Feldhausen.
		II. 0 P.M.		III. 13¾ P.M.	22 —	70·0	27·0	Feldhausen.
		III. 0 P.M.		IV. 13¾ P.M.	22 —	70·0	27·0	Feldhausen.
	Min. 35·0	X. 0 A.M.	21 Mar.	XI. 13¾ A.M.	21 —	70·0	35·0	Feldhausen.
		XI. 0 A.M.		O. 13¾ P.M.	21 —	70·0	35·0	Feldhausen.
	Diff. 8·0							
Exterior.	Max. . 38.4	XII. 0 NOON	22 Mar.	I. 13¾ P.M.	22 —	75·8	37·4	Feldhausen.
	Min. . 24·2	VI. 0 A.M.	21 Mar.	VII. 13¾ A.M.	21 —	67·0	42·8	Feldhausen.
	Diff. 14·2							

No. II.

TABLE of the maximum and minimum Pressure and Temperature of the Atmosphere during the Hourly Series of Observations for the March-Equinox, 1837, made by Sir JOHN HERSCHEL, at Feldhausen, near Wynberg, Cape of Good Hope; to which are annexed the Pressure and Temperature at the same instants of time at Mr. BELVILLE's Meteorological Observatory, Blackheath Road, near Greenwich.

BAROMETER.

Feldhausen. **Blackheath Road.**

	Time.		Corresponding Instant.			Diff. at the same Inst.	Place where the mer. col. was highest.
in.	h. m.		h. m.		in.	in	
Max. 29·844	IX. 0 A.M.	22 Mar.	VII. 46¼ A.M.	22 Mar.	29·836	0·008	Feldhausen.
Min. 29·705	I. 0 P.M.	21 Mar.	XI. 46¼ A.M.	21 Mar.	29·892	0·187	Blackheath Road.
Diff. 0·130							

THERMOMETER.

Feldhausen. **Blackheath Road.**

		Time.		Corresponding Instant.			Diff. at the same Inst.	Place where the mer. col. was highest.
	°	h. m.		h. m.		°	°	
Interior.	Max. 71·0	II. 0 P.M.	21 Mar.	O. 46¼ P.M.	21 Mar.	36·0	35·0	Feldhausen.
	Min. 69·0	VIII. 0 P.M.	21 Mar.	VI. 46¼ P.M.	21 Mar.	38·0	31·0	Feldhausen.
	Diff. 2·0							
Exterior.	DRY.							
	Max. 92·5	II. 0 P.M.	21 Mar.	O. 46¼ P.M.	21 Mar.	31·1	61·4	Feldhausen.
	Min. 54·5	I. 0 A.M.	22 Mar.	XI. 46¼ P.M.	21 Mar.	28·7	25·8	Feldhausen.
	Diff. 38·0							
	WET.							
	Max. 65·6	VIII. 0 A.M.	21 Mar.	VI. 46¼ A.M.	21 Mar.	not	ob-served.	
	Min. 51·3	I. 0 A.M	22 Mar.	XI. 46¼ P.M.	21 Mar.			
	Diff. 1·47							

A POPULAR COURSE OF CHEMISTRY.

XII.

NITROGEN.

IT is my intention to devote the present essay, to an examination of the curious compounds which *nitrogen* forms with *chlorine*, *iodine*, and *hydrogen*.

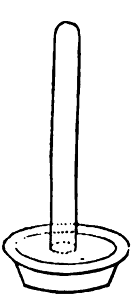
Chlorine and *nitrogen* have no *direct* action upon each other; that is, if you mix the gases in any proportion you choose, no change of their respective properties takes place; we therefore resort to *indirect* action, in order to cause their union, and produce the *chloride of nitrogen;* now, by *indirect* action, is meant the action of chlorine upon some *compound* of nitrogen, and that which we shall employ is the *muriate of ammonia*, ammonia being, as you will find hereafter, a compound o *nitrogen* and *hydrogen*.

I must here premise that the *chloride of nitrogen* is a most dangerously explosive substance; any greasy or oily matters will instantly cause it to explode with great violence; and therefore, before you begin experimenting upon its production, all the apparatus must be most scrupulously clean.

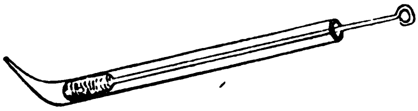
The pestle and mortar, basins, air-jars, and glasses, presently to be spoken of, may be cleansed from greasy or oily matters, by washing them out with a strong solution of *pearlash*, rinsing them well in water, and then wiping them dry with a perfectly clean cloth; and if you fold this round one end of a stick, long enough to reach the bottom of the air-jars, you can easily wipe their interiors dry.

Select a clean lump of *muriate of ammonia*, weighing about four ounces, reduce it to a moderately fine powder, in a clean Wedgwood mortar; measure out three pints of water; add some of this water to it, until it dissolves, and you can hasten the solution, by rubbing it round and round with the pestle; let it settle for a minute or so, then pour off the solution into a large clean basin, add more water to the muriate yet undissolved, rub it round with the pestle, pour off the solution as before, and so proceed, until the whole of the muriate is dissolved; this will probably happen before you have used the whole of the water, and if so, add the surplus of water to the solution in the basin, in order to reduce it to the degree of strength proper for the experiment, which is *one* part of the muriate in *twelve* of water. Now if the muriate and the vessels were all clean, the solution will be clean also; should it be turbid or dirty, it must be filtered through a filter made of white filtering paper, placed in a funnel; (see p. 271, Vol. III.;) but supposing it clean, pour some into a clean soup plate, until nearly full, cover this over with another plate, to keep out dust or dirt, then place it on the hob of the grate, until the solution just feels warm to your clean finger dipped into it, and when such is the case, remove it from the hob to the table.

The pneumatic trough being arranged with clean water, transfer some chlorine from your chlorine bottles, into an air-jar, about eighteen inches long, and three inches diameter, until it is completely full, and take particular care that no grease from the stoppers or mouths of the bottles touches the mouth of the air-jar, close it with a ground glass plate, or piece of stiff card, and having uncovered the plate containing the solution of the muriate of ammonia, quickly, yet cautiously, bring the mouth of the air-jar full of chlorine nearly to touch its surface, then remove the glass plate or card, and let the jar stand in the solution, as here shown. You will soon remark that the solution is gradually absorbed, and rises in the air-jar; a sort of oily film appears on its surface, it acquires a deep yellow colour, and presently globules like a yellow oil, collect upon the surface, and fall into the plate, where they coalesce into one large globule, having a beautiful bright golden yellow colour. This substance is the *chloride of nitrogen;* let its formation go on, until the solution nearly fills the jar, and the yellow colour of the atmosphere above it disappears, which will indicate to you that the whole, or nearly the whole, of the chlorine has entered into combination with the *nascent* nitrogen evolved by the decomposition of the *ammonia* in the muriate.



Well, then, you have succeeded in obtaining the compound; but the next question is, how are you to remove it from the vessels? The first thing to be done is to incline the air-jar a little on one side, so as to allow air to enter it very gradually, and thus displace the solution; this must be done cautiously, letting only small bubbles up at a time; and when the jar is thus emptied, take it out and place it on the table, with its mouth downwards, which will prevent your being annoyed by the escape of any excess of chlorine that it may chance to contain; the solution also has a strong odour of the gas, and you must take care not to inhale it.



The globule of *chloride of nitrogen*, or any portion of it, can be removed from the solution, by means of a small glass syringe, as shown in the annexed wood-cut. This is easily made by taking a bit of clean glass tube, about a quarter of an inch in diameter, and five or six inches long, holding one end of it in the flame of a spirit-lamp, until it becomes red-hot, and soft, then nipping the end with a pair of pliers, and suddenly drawing it out in a slanting direction; a long capillary tube is thus produced, which must be broken off to within half an inch of the bottom of the large tube. A straight piece of copper bell-wire, about seven inches long, must then be taken, and jagged with a knife at one end, so that it will hold enough fine tow or cotton, rolled round it, to fit the interior of the glass tube, and thus form a piston; the syringe is then completed; dip its small beak into a glass of clear water, draw the piston up and down, a few times, so as to bring it into proper action

The syringe being rather less than half full of water, plunge its orifice beneath the solution of muriate of ammonia, so as to touch the globule of the chloride of nitrogen; draw up the piston very gently, and a portion of the compound will enter the small beak; then raise the beak from the globule, and draw the piston up a little way, and in this manner the portion of the chloride will pass on, and repose in the angle of the tube; a drop of it, not larger than a grain of mustard seed, will be sufficient for one experiment; place the syringe and its contents in a saucer full of water.

Let an assistant* pour some olive oil on the surface of a sheet of paper placed on a table in the next room, or at all events, somewhere distant from your apparatus; and then if you take the syringe, hold it at arm's length, about a foot from the paper, and by pushing down the piston let the globule of the chloride fall upon the oiled surface; a powerful detonation attended by a vivid flash of light will instantly ensue, announcing the sudden decomposition of this singular substance by the contact of oily matter.

You can hardly be too cautious in these sort of experiments, and therefore it is as well to be provided with a mask, to prevent accidents happening to your eyes; a very good mask, is such an one as is used in fencing, only made of much finer wire gauze; or you may fasten around the front of a hat or cap, a piece of fine wire gauze, large enough to cover the whole of the face. I should strongly advise you to have one or other of these masks, during all your operations with this, or other detonating compounds.

A French chemist, named "Dulong, lost an eye, and the use of a finger, and Sir H. Davy was wounded in the face, by the effect of its explosion." If such accidents happened to these *skilful* chemists, how much more likely are they to occur to the *juvenile student!*

You may now proceed to exhibit the explosion of the compound in larger quantities; transfer, by means of the syringe, a globule of it, about the size of a small pepper-corn, into a saucer full of water; cover this over with a wire cage, like that of a "cage rat trap," only let the wires be closer together than even those of a "canary cage;" take a stick of wood, about four feet long, and slender enough at one end to pass between the wires, put the point of a pin or needle into this end, so that your assistant can stick a bit of phosphorus on it, about the size of a mustard seed. Your face being protected with the mask, hold the stick at one end, and thrust the other, on which is the phosphorus, between the wires of the cage, down through the water in the saucer, so that the phosphorus may touch the chloride; it instantly explodes, the saucer is shivered to fragments, but they are prevented from doing mischief, in consequence of being confined by the cage; the water, however, is thrown about with much force—but no danger can happen from that. This experiment, like the last, should be made either in another room, or out of doors. You must take care not to make it upon a table of any beauty or value, because the explosion will drive the fragments of the saucer into it and completely spoil its surface.

The only character of the chloride of nitrogen that can be exhibited with any degree of facility, is its explosion, and this, according to Messrs.

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* I say let an assistant do this, in order that you may not run the chance of soiling your own hands with the oil.

Porret, Wilson, and Kirk, (who made a very extended set of experiments upon the subject,) is most readily effected by greasy or oily bodies, phosphorus, and fused potassa, but not by the metals, resins, and sugar.

Sir Humphry Davy found the specific gravity of *chloride of nitrogen* to be about 1·6; that is, considerably heavier than water; it does not congeal by cold, and has a very peculiar irritating odour; it very soon entirely evaporates, by exposure to air. Mercury, and some other metals, slowly decompose it, by absorbing its chlorine, and evolving its nitrogen; and by a slow action of this kind, Sir Humphry analysed the compound, and determined its composition to be 1 proportional of nitrogen = 14; and 3 proportionals of chlorine = 108; its representative, or equivalent number, = 122; it is, therefore, a *terchloride* of *nitrogen*.

Chloride of nitrogen was discovered by Dulong, about the beginning of 1812; it was then called "Detonating Oil," but its preparation was kept secret, on account of the sanguine expectations entertained by the French, of employing it as a most destructive agent in naval warfare. Sir H. Davy, understanding that chlorine and nitrogen were concerned in its formation, instituted a course of experiments, in order to effect the combination of the two bodies, and he discovered the mode already detailed for its production, as likewise its true nature and properties.

We have now to examine the compound of *iodine* and *nitrogen*.

Iodine and *nitrogen* have no *direct* action upon each other, but by presenting iodine to *nascent* nitrogen, the two elements combine and produce an *iodide of nitrogen*, which is the most explosive substance hitherto known.

The easiest method of producing it is the following:—Take a small wine-glass, and pour into it about an ounce of strong aqueous solution of ammonia (*liquor ammoniæ*), to which, add about twenty grains of iodine; stir it round two or three times with a bit of glass rod, or the stem of a clean tobacco pipe, and then leave it at rest for about half an hour.

In this experiment, the following decomposition takes place:—*Ammonia* consists of *hydrogen* and *nitrogen*, the *iodine* decomposes a part of it, combining with its *hydrogen* to form *hydriodic acid*, which unites to an undecomposed portion of ammonia to form *hydriodate of ammonia;* the *nascent nitrogen* evolved from the decomposition of the first portion of ammonia, meeting with a portion of *free iodine*, combines with it to form the *iodide of nitrogen*.

Now during the time that this singular and somewhat complicated change of elements is going on, you can occupy yourself in making the following arrangement, for the purpose of drying the iodide presently.

Take half a dozen pieces of white filtering-paper, about the size of this page, and double each piece into four thicknesses; place these pieces in different parts of the laboratory, as far distant from each other as may be, some, for instance, in cupboards, others on shelves, &c.; the reason for thus dispersing them will presently appear.

If you now examine the contents of the glass, you will find at the bottom of the liquid a considerable portion of a brownish black powder; it is the *iodide of nitrogen*, from which you must pour off the supernatant liquid (which is useless), and then with a slip of stout card, or a small wooden or ivory knife, take out a portion of the powder, about the size of a pepper-corn, and place it on the centre of one of the pieces of filtering paper; this being done, take out another similar portion, and place it on another paper, and so on, until you have removed it all from the glass, which may then be washed out with water.

The filtering paper draws away the moisture from the iodide, and by a few hours' exposure to air, it will become perfectly dry, and is then eminently explosive; indeed, it often explodes spontaneously; and the explosion of one portion almost invariably causes that of the others in its vicinity, hence the precaution of putting the respective portions at some distance from each other. I should advise you to set about the formation of the iodide rather late in the evening, so that when you have disposed of it on the papers, it may have the whole night to dry spontaneously and undisturbed, for if you work in the laboratory whilst it is drying, the chances are, that it may explode, by the agitation of the air, caused by your moving about, or some accidental vibration of the shelves, &c., on which it is placed.

In the morning, then, the iodide will be ready for examination; it appears as a brownish black powder, of a somewhat shiny appearance; and it will detonate upon the slightest touch; if you take hold of the piece of paper on which it is placed, it is almost sure to detonate, and will infallibly do so if you let it fall to the ground, or touch it with the edge of a card; the detonation is a sharp crack, like that of a hunting-whip; a hole is rent in the paper by its force, and violet fumes of iodine are perceptible at the moment.

There is no danger in making the detonation in this way, and you must not attempt to make it in any other; it is almost needless to caution you not to attempt to put the iodide into any glass, or other vessels, for it would detonate during the act of transferring, and blow the vessel into fragments, to the hazard of your eyes.

When it detonates upon paper, no harm can happen, because the gaseous matters have free and instant escape. Very slight causes will decompose the iodide with detonation; it often detonates spontaneously during drying, and it is no uncommon thing, when you come to look for it in the morning, to find that such has been the case, as the rent and torn papers testify; and therefore you have your work to do over again; if you open or shut the door of the laboratory very suddenly, it is almost sure to explode, and the detonation of one portion generally causes that of all the others—so you must be extremely cautious how you examine this very curious and remarkable compound.

It was discovered by Courtois in 1812, or 13, and was examined with much care and skill both by Sir H. Davy and M. Gay-Lussac; they succeeded in analysing it, and determined its composition to be 1 proportional of *nitrogen* = 14, and 3 proportionals of *iodine* = 375; its representative, or equivalent number, therefore, = 389. It is, therefore, a *teriodide of nitrogen.*

In taking leave of these two explosive compounds, I must once more, and at the risk of being thought very tiresome, request you to be cautious in your experiments with them, and never to prepare or explode them in large quantities.

We have lastly to consider a very curious compound of *hydrogen* and *nitrogen;* namely, *terhydruret* of *nitrogen*, better known as *ammonia*, or *volatile alkali.*

Hydrogen and *nitrogen* have no *direct* action upon each other, but they combine under certain circumstances, and produce *ammonia*, which, under ordinary circumstances, is a gaseous body. You may procure it by the action of *quicklime* upon *muriate* of *ammonia;* if you cannot easily obtain some quicklime from the builders, you must prepare some in the following manner; take a moderately large earthenware crucible, and fill it with powdered whiting or chalk, place it in a fire, and keep it at a strong red heat for two hours; whiting and chalk are *carbonates of lime;* and by the action of heat you drive off the *carbonic acid*, and *quicklime* remains in the crucible; let it cool, and then take out a spoonful or two, place it on a plate, and drop a little water on it, if it *slakes*, and evolves *heat*, you may conclude that it is properly calcined; reduce it all to a fine powder, which must be preserved in a bottle closely stopped. Powder also two or three ounces of *muriate of ammonia*, tolerably fine, and put it into a bottle ready for use.

Now take a Florence flask, perfectly dry inside; find a cork that will fit its neck accurately, make a round hole through the cork with a "rat-tail file," large enough to fit one end of a bit of glass tube about half an inch in diameter, and twelve inches long, into which you must place a long folded strip of filtering paper; the next things that you require are four or five stoppered bottles perfectly dry inside, and the stoppers slightly greased, and now you will be ready for work.

Weigh out two ounces of *quicklime*, and one ounce of the *muriate of ammonia*, mix them quickly together by rubbing them in a mortar, then place the mixed powder on half a sheet of paper; you will find a very pungent odour evolved in doing this, which odour is that of *ammonia;* you must now pour the mixture into the flask as quickly as you can, and then insert the cork with the glass tube, set the flask on a retort stand, and steady it by means of an upper ring, as shown at p. 364, Vol. III.

Now heat the bottom of the flask gently with the flame of a spirit-lamp, and hold a bit of turmeric paper to the end of the tube; if its yellow colour is reddened, *ammonia*, or *volatile alkali*, is evolving; and when the reddening becomes very intense, you may proceed to collect the gas, by putting one of the glass bottles, with its mouth downwards, over the end of the tube, so that the tube quite touches its bottom, and the bottle will safely hang on it.

Gaseous ammonia, or *ammoniacal* gas, is very light as compared with air, and therefore it rises into the bottle, expelling the air, and you may judge when the bottle is full of the gas, by holding a bit of turmeric paper to its mouth; if the test paper is strongly reddened, you may remove the bottle, holding its neck still *downwards*, and having put in the stopper, place it on the table in its usual position; put a fresh bottle on the tube, when it is filled remove it in like manner, and so go on until no more gas comes off. Towards the end of the process, a little water will rise from the materials in the flask; this will be absorbed by the filtering paper in the tube.

If you succeed in getting four or five "eight ounce bottles" full of the gas, you will have enough to experiment upon.

The theory of its production in this process is rather difficult for you to understand just at present, but perhaps, I can render it intelligible by premising the composition of *quicklime;* it is a compound of *oxygen*, and the metal *calcium*, and is therefore an *oxide of calcium.*

Muriate of ammonia is a compound of *muriatic acid* and *ammonia. Muriatic acid* is a compound of *hydrogen* and *chlorine;* when oxide of calcium and muriate of ammonia are heated together, the *oxygen* of the oxide of *calcium* unites with the *hydrogen* of the muriatic acid, to form water. The *calcium* unites with the *chlorine* of the muriatic acid to form *chloride of calcium;* and the muriatic acid being so decomposed, the *ammonia* with which it was combined is expelled in its pure *gaseous* state.

Ammonia is a gas at all common temperatures and pressures, but Dr. Faraday succeeded in causing it to assume the *liquid* state, by reducing it to the temperature of $-50°$ under a pressure of 6·5 atmospheres, so that it merits the title of a *vapour* rather than that of a gas; (see Vol. I., p. 294;) however, you cannot easily succeed in causing its liquefaction, and must be contented with an examination of its properties in its ordinary state.

During the operation of collecting it, you will have discovered its peculiar pungent odour, like that of strong *hartshorn;* you must not venture to smell the gas, either from the tube, or any of the bottles, because it is there nearly pure, and intensely pungent and acrid; it would produce very dangerous effects—deprive you of your breath in an instant.

You have seen that it is *alkaline*, (it was formerly called *alkaline air*,) but the effect which it produces on the test paper is transient; the original yellow colour returns upon a few minutes' exposure to air, or more quickly, by holding it to the fire, the *ammonia* flies off, and hence it is called *volatile alkali*, to distinguish it from potassa, soda, &c., the *fixed alkalies*, which permanently redden the test paper.

Ammonia neutralizes the acids, and produces an important class of compounds, called *ammoniacal salts*, some few of which I shall have occasion to notice by and by.

I have already said, that it is a very light gas, its specific gravity, as compared with air, being as 0·590 to 1; and compared with hydrogen as 8·5 to 1.

It extinguishes flame, as you can easily prove, by placing a lighted taper in a bottle of it, with the neck turned downwards; and when you have ascertained this fact, place the neck of another bottle full in a saucer containing a little water, which will rapidly absorb the ammonia, furnishing you an aqueous solution, which retains the pungent odour of the gas, and exerts a similar action on the test paper.

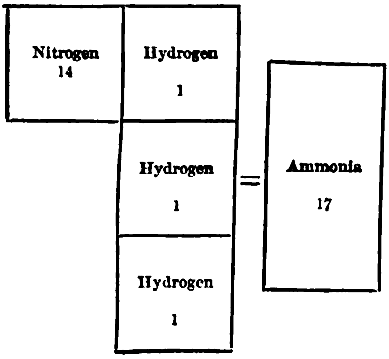
It is in the state of solution that ammonia is generally employed in the chemical laboratory. We do not often form the solution by the direct absorption of the gas by water, but by distilling the mixture of quicklime and muriate of ammonia along with water, which in this manner comes over strongly impregnated with ammonia.

Make a mixture of *slaked lime* and muriate of ammonia, in the same proportions as already directed, put it into a retort, with about a pint of water, and proceed to distillation in the same arrangement of apparatus as that shown at page 359, Vol. III.; you will collect in the bottle a considerable quantity of aqueous solution of ammonia, *liquor ammoniæ*, as the operative chemists call it, and from whom you may purchase it whenever you require any considerable quantity.

Liquor ammoniæ must be preserved in a well-stoppered glass bottle, or otherwise the ammonia will fly off to a very great extent, or absorb carbonic acid from the air.

The results of many experiments upon *ammoniacal gas*, agree in proving it to consist of 1 proportional of nitrogen $= 14 + 3$ proportionals of hydrogen $= 3$; its equivalent, or representative number, is therefore $= 17$.

The annexed diagram will serve to show you the weight and volumes of the gases, and their *condensation* by union into the space of *two* volumes.



Such being the elements of ammonia, you will understand how it is evolved by the decomposition of organic bodies, consisting of carbon, oxygen, hydrogen, and nitrogen. If you burn a quill or a feather, you know that a very pungent odour is evolved; this is due to the hydrogen and nitrogen uniting to form ammonia. Put a few chips of quill into the bottom of a glass tube sealed at one end, about half an inch in diameter, and six inches long; then thrust into the upper part a small strip of turmeric paper; heat the end of the tube containing the quill with the flame of a spirit-lamp; it begins to scorch and blacken, and emits a large quantity of fumes, which will redden the turmeric paper, in consequence of containing *ammonia;* the original yellow colour of the paper will return, if you take it out and place it on the warm part of the tube.

Nearly all animal matters evolve ammonia when thus decomposed by heat; indeed, the result is so general, that it is looked upon as a tolerably accurate test of the presence of an animal substance. If you heat a bit of wood exactly in the same manner, there is no evolution of ammonia, because wood, and most other vegetable substances, consist of carbon, oxygen, and hydrogen—the nitrogen is wanting, and therefore ammonia cannot be formed. *Vinegar*, or *acetic acid*, is abundantly produced, as you will find, if you test the fumes with litmus paper; it becomes reddened: acetic acid consists of carbon, oxygen, and hydrogen.

In some *animal* matters, however, *nitrogen* is wanting,—this is the case with *fat;* it consists of carbon, oxygen, and hydrogen only. And in some *vegetable* matters, *nitrogen* is present,—this is the case with *fungi*, which consist of carbon, oxygen, hydrogen, and nitrogen; they produce ammonia. Therefore you must not regard the production of ammonia as an *infallible* test of the presence of animal matter, as the following experiment will still further show.

If you pour some strong nitric acid on tin, exactly as directed at p. 366, Vol. III., the metal will become oxidized by the decomposition of the acid; part of whose *nitrogen* will be evolved, and in the nascent state will combine with part of the *hydrogen* of the water which is present, and form *ammonia:* this instantly unites with a portion of undecomposed acid to form *nitrate of ammonia.* When the glass is cool, pour in some quicklime, and stir it about, at the same time holding a bit of turmeric paper to the mouth of the glass; it will be immediately reddened, and indeed the evolution of ammonia is evident by its smell; it is evolved in consequence of the quicklime decomposing the nitrate of ammonia.

There is a very pretty and instructive experiment, showing the existence of nitrogen in ammonia, which you can easily make as follows:

Prepare about eight ounces of strong aqueous solution of chlorine, as directed at p. 292, Vol. II., and pour this into a glass tube, about three-fourths of an inch in diameter, and two feet long, to within two inches of the top, then fill it up with strong aqueous solution of ammonia *(liquor ammoniæ);* place the thumb over the open end of the tube, and invert it beneath the water in the pneumatic trough; remove the thumb, the ammonia rises through the solution of chlorine, is decomposed with effervescence, and *nitrogen* collects in the upper part of the tube; the *hydrogen* unites with part of the *chlorine* to form *muriatic acid*, which unites to a portion of undecomposed ammonia, to form *muriate of ammonia*, which remains in solution. That the gas thus collected is *nitrogen*, you can ascertain by its extinguishing flame, &c., as directed at p. 174, Vol. III.

There is no such compound as a *chloride of ammonia;* for whenever *chlorine* and *ammonia* are presented to each other, the latter undergoes partial decomposition; nitrogen is evolved, and muriatic acid formed, which combines with an undecomposed portion of ammonia to form a *muriate of ammonia.*

You can obtain this salt by saturating *muriatic acid* with *liquor ammoniæ*, and gently evaporating to dryness in a small saucer. The muriate then appears as a white substance, having all the characters of the well-known salt called *sal ammoniac*, which you will remember was our source of gaseous ammonia at the outset of this inquiry.

You may produce it in another way; although in quantity too small to be collected, yet it will show you the affinity of the two substances for each other. Wet the insides of two large tumblers, the one with *muriatic acid*, the other with *liquor ammoniæ*, then bring their mouths together; a dense white fume is produced, which is *muriate of ammonia*, in a state of extremely minute division.

The experiment admits of another modification:—Take two wine glasses; place in one a few lumps of muriate of ammonia, and in the other powdered muriate of ammonia and quicklime; place them close together on the table, pour a little sulphuric acid into the first glass, and cover both glasses with a large bell glass; the materials in the one instance evolve *muriatic gas*, and in the other *ammoniacal gas;* these meeting each other will fill the bell glass with dense white fumes of *muriate of ammonia.*

Muriate of ammonia consists of 1 proportional of muriatic acid

=37+1 proportional of *ammonia* =17; its equivalent number is therefore = 54. As it is a very abundant article of commerce, chemists rarely form it for their experiments; it is produced by the decomposition of *sulphate of ammonia*, by *common salt*, or *chloride of sodium*, on a very large scale; and as it sublimes by heat, it is generally met with in large thick cakes, as broken out of the subliming vessels. By cautiously evaporating its aqueous solution, you may obtain it in crystals, which are cubic, octoedral, or plumose, according to circumstances. It is very much employed in the arts, especially in tinning copper vessels. It prevents the surface of copper from oxidizing, keeps it clean, and the melted tin readily adheres. From the circumstance of its having originally been procured from the neighbourhood of the Temple of Jupiter Ammon, it received the name of *Sal Ammoniac*, by which it is commonly known at the present day; and hence the origin of the term *ammonia*, which, strictly speaking, is a *terhydruret of nitrogen*.

There is only one other ammoniacal salt of any importance, that can now be spoken of, viz. the *nitrate of ammonia;* and I have already shown you how to form it, (p. 175, Vol. III.) for the production of *nitrous oxide*. I need do no more at present than advert to its composition, in order to explain to you the theory of the production of the above gas. *Nitrate of ammonia* consists of 1 proportional of *nitric acid* = 54+1 proportional of *ammonia* =17; the equivalent number is, therefore, =71. When heated, the three proportionals of *hydrogen* of the ammonia combine with *three* proportionals of the *oxygen* of the nitric acid, forming *three* proportionals of *water*, whilst the 1 proportional of the *nitrogen* of the ammonia, and the 1 proportional of the nitrogen of the nitric acid, unite with the *two* remaining proportionals of *oxygen*, forming *two* proportionals of *nitrous oxide*.

ON SPIKE DRIVING.

EXPERIMENTS ON THE ADHESION OF IRON SPIKES OF VARIOUS FORMS, WHEN DRIVEN INTO DIFFERENT SPECIES OF TIMBER.

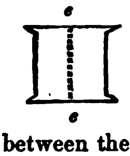
IN reference to rail-road constructions, bridge-building, and several other useful applications in civil engineering, as well as in naval architecture, the adhesion of spikes, bolts, and nails of various forms, becomes an object of much practical importance. With regard to rail-roads, this matter is worthy of more attention than might at first sight be supposed. Owing to the present high price of iron, the flat rail is often unavoidably adopted in preference to the edge rail, and whenever the speed of a train, descending by gravity or impelled with great velocity by the moving power, is to be suddenly checked by the brake, the friction of the periphery of the wheel on the rail tends to drive the latter lengthwise, and thus to force all the spikes with which it is fastened into closer contact with the ends of the fibres which have been cut in driving them. If this partial or total dragging of the wheels along the rails takes place, sometimes in one direction, and sometimes in the other, the spikes must be subjected to alternate impulses on opposite sides. Indeed, whenever the motive power depends on friction for its efficacy, as in the case of the common locomotive engine, there is a constant succession of these two opposite dragging forces, the engine constantly tending by its driving wheels to urge the rail backward, and the train by an equal, but more extensively distributed action, tending to urge forward all the rails over which it is, at the same moment, passing. So decided is this influence, that on a rail-road where the transportation is all in one direction, and where the cars descend by gravity, I have seen rails entirely detached, or loosely connected but by a single spike, while others clearly indicated by the inclined position of their upper faces or heads, that they were pressed into an oblique or leaning position in the wooden sill. This single case may serve to show the importance of attending to the character of the spikes used in similar constructions.

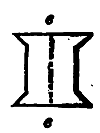
To determine some of the points relating to the form of spikes, and the kind of timber into which they are driven, the following experiments were undertaken, they serve to show the relative economy of each form of spike, as well as its absolute fitness for the purpose intended.

The mode of executing the experiments was to drive each spike, to a certain distance above its cutting edge, into the edge of a piece of plank or scantling, and, by means of a suitable apparatus adapted to that purpose, to draw it out by a direct longitudinal strain. The machine employed for this purpose was the same as that which has been used for testing the strength of iron and copper in experiments on the tenacity of materials employed in steam-boilers. A strong band or strap of iron connected with the weighing beam of that machine held the piece of plank, and a clasped pincers, with a suitable jaw, for taking hold of the head and projecting part of the spike, was attached to the opposite part of the machine, which, being tightened by a strong screw, held the spike firmly while the application of weights upon the longer arm of the lever drew the timber away and released the spike. Care was taken to cause the strain to pass through the axis of the spike, and, by a very gradual application of weights, to avoid surpassing that force which was just sufficient for its extraction.

The first experiment was upon one of Burden's patent square spikes with a cutting edge, intended to be, in all cases, placed across the grain of the timber. This spike was ·375 inch square, and was driven into a sound plank of seasoned Jersey yellow pine $3\frac{3}{8}$ inches. The force required to extract it was 2052 lbs. The exact weight of the part driven into the wood was 866 grains troy.

The second trial was upon a flanched, grooved and swelled spike, having the grooves between two projecting wings or flanches on the same sides as the faces of the cutting edge. The other two sides were planes continuing to the head. A cross section of this spike taken $1\frac{3}{4}$ inches above its edge or point, had the form of the figure annexed. At $\frac{8}{10}$ of an inch from the edge, that is, where the flanches project least, or where the *swell* between them comes nearest to forming a perfect square, the figure is as follows:—the dotted line *e e* in each figure representing the direction of the cutting edge. Towards the head of this spike, the flanching and grooving is suppressed, and the form becomes a square. This experiment was made on the same piece of Jersey yellow pine as the first, and the weight required for extracting the spike was 1596 lbs.; the weight of the part driven in was $708\frac{1}{4}$ grains. The cutting edge was ragged and irregular. The distance to which it was driven was $3\frac{3}{8}$ inches, as in the first trial. To know the relative values of the two forms of spikes, we have but to divide the weight required for the extraction of each by the number of grains in the part which had been buried in the wood. Thus $2052 \div 866 = 2{\cdot}37$, and $1596 \div 708{\cdot}25 = 2{\cdot}112$. Hence the plain spike had an advantage over the swelled and grooved one, in about the proportion 23 to 21. It should be mentioned, also, that the plain spike was drawn out by a very gradual addition of force; whereas the force of 1596 lbs. drew the grooved spike immediately after its application. In the first trial, an attempt was made to detect any yielding or gradual retreat of the spike before the final start, but none was perceived.





The third and fourth experiments were made with the same spikes respectively as the first and second; but instead of yellow pine the timber employed was thoroughly-seasoned white oak.

The plain spike driven $3\frac{3}{8}$ inches into that timber, required for its extraction a force of 3910 lbs., and, as before, exhibited no signs of movement until the instant of starting, when it suddenly came out about a quarter of an inch, or as far as the range of motion, and the elasticity of the machine, would permit.

The flanched, swelled and grooved spike driven $3\frac{3}{8}$ inches into another part of the same piece of plank, from which the plain one had been extracted, was drawn out with a force of 3791 lbs. A slow motion to the extent of $\frac{1}{25}$ or $\frac{1}{20}$ of an inch was in this trial perceived to precede the starting of the spike; and was accompanied by a gradual protrusion of the fibres of the timber immediately around the iron.

In these experiments, though the plain spike bore the greater absolute weight, yet, when the weight of metal is considered, it is seen that the relative values of the two are 4·515 in the plain, and 5·354 in the grooved form.

The various circumstances of the four preceding experiments are seen at a single view in the following Table:

TABLE I.

No. of the Exp.	Kind of Spike used.	Kind and Condition of the Timber.	Breadth of the Spike.	Thickness of the Spike.	Depth to which it was driven.	Weight in Grains of the part inserted.	Force to extract the Spike, in lbs. Avoirdup.	Ratio of the extracting Force to weight of Spike.	REMARKS.
			Inch.	Inch.	Inches.				
1	Plain square Spike (Burden's.)	Seasoned Jersey Yellow Pine.	·375	·375	3·375	866	2052	2·368	Force gradually applied; no motion previous to the start.
2	Flanched, grooved, & swelled.	Do.	·375	·300	3·375	708	1596	2·254	Force applied, at once.
3	Burden's plain.	Seasoned White Oak	·375	·375	3·375	866	3910	4·515	Started suddenly.
4	Grooved and swelled.	Do.	·375	·300	3·375	708	3791	5·354	Fibres protruded 1.20 of an inch before the spike drew out.

Hence it appears that in yellow pine the grooved and swelled form was about five per cent. less advantageous than the plain, while in the seasoned oak the former was 18½ per cent. superior to the latter. It is also apparent that the advantage of seasoned oak over seasoned yellow pine for retaining spikes is, by a comparison of experiments, 1 and 3, as 1 to 1·9; and by a comparison of 2 and 4 it is as 1 to 2·37. In the preceding experiments, the spikes were driven into the timber, and immediately drawn out again. In the second series, the spikes were driven into their respective pieces of timber, and then soaked for a few days in water. The pieces into which different spikes were driven, were as nearly alike as it was practicable to obtain them, being always cut from the same plank, avoiding knots, cracks, &c.

The following Table contains a view of the experiments made after soaking the timber:—

TABLE II.—Timber soaked after Spikes were driven.

No. of the Exp.	Kind of Spike used.	Kind and Condition of the Timber.	Breadth of the Spike.	Thickness of the Spike.	Depth to which it was driven.	Weight in Grains of the part inserted.	Force to extract the Spike, in lbs.	Ratio of the extracting Force to weight of Spike.	Remarks.
			Inch.	Inch.	Inch.				
1	Swelled and grooved.	Chestnut, unseasoned.	·375	·300	3·5	806	1710	2·121	In this and the four following experiments, the thickness of the spike is that found at the bottom or hollows of the grooves.
2	Do.	YellowPine seasoned.	·375	·300	3·5	806	1668	2·069	
3	Do.	Hemlock, partly seasoned.	·375	·300	3·5	806	1738	2·156	
4	Do.	White Oak seasoned.	·375	·300	3·5	806	3373	4·184	The oak used in this experiment was firmer than that employed in the first series.
5	Do.	Locust, partly seasoned.	·375	·300	3·5	806	4902	6·081	The timber had been slightly split by driving.
6	With the swell filed away.	Unseasoned Chestnut.	·390	·300	3·5	759	1852·5	2·440	The flanches remained after filing out the swelled part of the original form.
7	Do.	Seasoned Yel. Pine.	·390	·300	3·5	759	1767	2·328	
8	Do.	Hemlock, partly seasoned.	·390	·300	3·5	759	1296·8	1·576	
9	Plain spike draw-filed lengthwise.	Chestnut, unseasoned.	·400	·394	3·625	933·5	1790	1·810	
10	Do.	Hemlock, partly seasoned.	·400	·394	3·5	933·5	1638·75	1·755	
11	Do.	Locust partly seasoned.	·400	·394	3·5	933·5	3990	4·167	
12	Do.	Do.	·400	·394	3·5	933·5	4332	4·640	Timber slightly split in driving the spike.
13	Grooved and notched or serrated.	White Oak	·392	·315	3·625	759	2622	3·454	
14	Burden's *Patent.*	*Do.*	·339	·229	3·625	639	2152	3·367	

The first five of the preceding experiments show that with a spike of given form, and driven a certain distance into different timbers, the order of retentiveness, beginning with the highest, is as follows: 1. Locust; 2. White Oak; 3. Hemlock; 4. Unseasoned Chestnut; 5. Yellow Pine.

From the 6th, 7th and 8th experiments, we see that chestnut is still above yellow pine, but that hemlock is inferior to both. By the 9th and 10th, it also appears that hemlock is still to be placed below chestnut. Comparing the 1st experiment in this table with the 6th, and the 2nd with the 7th, we perceive that the swell towards the point of the grooved spike was so far from being an advantage to it, that it, in fact, rendered the spike less retentive than when that swelled part had been removed, so that even could this form have been produced without any increase in the weight of the spike, it would still have been less advantageou than the simple groove without the swell, but when it is considered that the swell added 47 grains $(806-759)$ to the weight, it is evident that the groove alone has a decided advantage over the other form. By the trials in unseasoned chestnut (Nos. 1 and 6) this advantage is 15 per cent. thus $\frac{2440-2121}{2121}=15.$ and by those on yellow pine (Nos. 2 and 7) it is $\frac{2328-2096}{2096}=12\cdot5$ per cent.

In fact, after the ends of the fibres have once been thrust apart by the thick part of the swell, it is evident that when they come opposite to the cavity, above the swell, they must lose some part of their power to press the spike and to produce the retaining force of friction. This force must then depend for its production on the action of those fibres of the wood which are opposite to the swelled portion, or between it and the points of the spike.

In the next series of experiments it was attempted to ascertain the relation between forms more diversified than had hitherto been employed.

As it is evident that the total retentiveness of the wood must depend, in a considerable degree, upon the number of fibres which are longitudinally compressed by the spike, it was inferred that on the area of the two faces which, in driving the spike, are placed against the ends of the fibres, must, in a great measure, depend the retention of the spike, In this series, four kinds of wood and ten forms of spikes were employed.

A comparison of the results, given in the following table, will show what order these *forms* would possess among themselves, in point of retentiveness, as well as the advantages of the respective species of timber into which they were severally driven.

TABLE III.—Spikes of various Forms—Timber of different Kinds.

No. of the Exp.	Kind of Spike used.	Kind and Condition of the Timber.	Breadth of the Spike, in Inches.	Thickness of the Spike, in Inches.	Area of 2 Faces, in square Inches.	Depth to which driven, in Inches	Weight in Grains of the part inserted.	Force to extract the Spike, in lbs. Avoirdupois.	Ratio of the extracting Force to weight of Spike.	Remarks.
1	Straight square.	Chestnut, unseasoned.	·405	·402	2·83	3·5	942	1995	2·116	
2	Burden's Patent.	Do.	·373	384	2·64	3·5	866	1873	2·162	
3	Broad flat.	Do.	·539	·288	3·77	3·5	898	2394	2·663	
4	Narrow do.	Do.	·390	·253	2·73	3·5	566	2223	3·927	
5	Straight square.	White Oak thoroughly seasoned.	·405	·402	2·83	3·5	942	3990	4·129	
6	Broad flat.	Do.	·539	·288	3·77	3·5	898	5130	5·712	
7	Narrow do.	Do.	·390	·253	2·73	3·5	566	3990	7·049	
8	Burden's Patent.	Do.	·373	·384	2·64	3·5	866	3905	4·509	
9	Cylindrical with cutting Edge.	Do.	diam ·485	..	..	3·5	1211	3876	3·200	
10	Grooved and swelled.	Do.	·375	·375	2·60	3·5	806	3727	4·624	The measures in this and two following cases, taken outside of flanches.
11	Grooved but not swelled.	Do.	·375	·375	2·60	3·5	759	4247	5·662	
12	Grooved; bottoms serrated.	Do.	·375	·375	2·60	2·5	500	2650	5·300	The weight of part inserted is given by estimation in this Experiment.
13	Square.	Locust. seasoned for 3 Years.	·405	·402	2·83	3·5	942	5967	6·334	
14	Broad flat.	Do.	·539	·288	3·77	3·5	898	7040	7·839	
15	Narrow do.	Do.	·390	·253	2·73	3·5	566	5273	9·316	
16	Cylindrical pointed; 15 grooves, filed longitudinally.	Ash, seasoned.	diam ·500	..	..	3·5	929	2052	2·208	In this and the two following Experiments, the Spikes were driven into the Timber in the direction of the length of the fibres
17	Do.	Do.	.500	..	..	3·5	929	2309	2·507	
18	Plain cylindrical pointed.	Do.	·500	..	..	3·5	1015	2451	2·414	

The above table furnishes three sets of comparisons for deducing the relative retentive powers of green chestnut, thoroughly seasoned oak, and equally seasoned locust. Thus the weight, which in those three cases drew the square spike from chestnut, was 1995 lbs. That which extracted the broad flat one, 2394, and that which drew the narrow flat one, from the same timber, was 2223. The sum of these is 6612. The sum of the three numbers for the same three spikes used with oak, was, by experiments 5, 6, and 7, 13110; and the same of the three in locust, by experiments 13, 14, and 15, is 18280; these three numbers have to each other the relation of 1, 2, and 2¾, from which we infer that oak is almost precisely *twice*, and locust 2¾ times, as tenacious as unseasoned chestnut. By comparing together the results of experiments 1 and 2, it will be seen that the weights required for extracting the two spikes respectively, are more nearly proportional to the breadths than to either the thicknesses or the weights of the spikes, for the spike with a breadth of ·405 inch, and a thickness of ·402, required 1995 lbs. for its removal, while that which had a breadth of ·375 inch, took 1873 lbs.

Now ·373 : ·405 : : 1873 : 2033 for the calculated retentiveness, instead of 1995 as given by experiment,—a difference of only + 38 lbs. between the observed and calculated results. Calculating the retention by the *weights* of the respective spikes, we should have 866 : 942 : : 1873 : 2037, or a difference of 42 lbs; while using the *thicknesses* alone, we obtain ·384 : ·402 : : 1873 : 1960, a difference of an opposite kind of 35 lbs. from the observed result. The greater thickness yielding the less retentive power. This correspondence between the breadths and the extracting weights becomes still more apparent, when we compare the *third*, and especially the *fourth*, with the *second* experiment. Thus for the broad flat spike (3d experiment) compared with experiment 2nd, we have,

By breadths ·373 : ·539 : : 1873 : 2701, instead of 2394, diff. + 307
By weights ·866 : ·898 : : 1873 : 1942 . . . . " − 452
By thicknesses ·384 : ·288 : : 1873 : 1379 . . . . " − 1015

And for the thinner and lighter spike (experiment 5th) compared with No. 2., we have,

By breadths ·373 : ·390 : : 1873 : 1958, instead of 2223, observed diff. − 265
By weights ·866 : ·566 : : 1873 : 1224 . . . . . " − 999
By thickness ·384 : ·253 : : 1873 : 1234 . . . . . " − 989

Nearly the same conclusions would result from a comparison of those trials which were made on seasoned white oak and locust. Indeed it appears that, with a given breadth on the face of the spike, a diminution of thickness is sometimes a positive advantage to the retentiveness of the timber, for on white oak the spike which had a breadth of only ·390, required as much force to extract it, as one of which the breadth was ·405—though the thickness of the former was but ·253, while that of the latter was ·402, and on chestnut the thinner, narrower and lighter spike required absolutely more force to withdraw it than the other. This leads us to notice the different kinds of action of the respective spikes on timbers of various kinds.

In the softer and more spongy kinds of wood, the fibres, instead of being forced back longitudinally and condensed upon themselves, are, by driving a thick, and especially a rather obtusely pointed, spike, folded in masses backward and downward, so as to leave, in certain parts only, the faces of the grain of the timber in contact with the surface of the metal.

That the view just presented is correct, seems also probable, from what was observed in the case of the swelled spike. For while the grooved but *unswelled* one driven into chestnut timber (Table II. Ex. 6,) required 1852 lbs. to extract it, the grooved and swelled one (Ex. 1. same table,) took but 1710. And in Table III. Ex. 2, we find the swelled spike drawn from white oak by 3727 lbs., and the grooved but not swelled one (Ex. 12,) requiring 4247. Hence, it appears to be necessary, in order to obtain the greatest effect, that the fibres of the wood should press the faces as nearly as possible in their longitudinal direction, and with equal intensities throughout the whole length of the spike.

Arranging the spikes according to the order of their ratios of *retention to weight*, as given by the experiments from 5 to 12, inclusive, in Table III., we have the following:

1. Narrow flat, with a ratio of	7·049
2. Wide flat	5·712
3. Grooved but not swelled	5·662
4. Grooved and notched	5·300
5. Grooved and swelled	4·624
6. Burden's patent	4·509
7. Square hammered spike	4·129
8. Plain cylindrical	3·200

Experiments 16, 17, and 18 of the same table were made by driving the spikes, which were cylindrical with conical points, into the timber endwise of the grain. This method of comparing two forms, the one grooved, and the other plain, was adopted on account of the extreme liability of the timber to be split by driving spikes of these forms across the direction of the fibres. It was observed, that on drawing these spikes the holes were almost perfectly square. This resulted from the position of the rings of annual growth, and the greater elasticity in some directions than in others. It is probable that, if the filed grooves, in experiments 16 and 17, had been covered with a scale of oxide, as was the case with the plain spike used in experiment 18, the former would have given a somewhat higher result. When holes are drilled into stone blocks, and afterwards plugged with timber to receive spikes, in fastening on the chairs of edge rails, the method of experimenting just described finds an application, and it is probable that in such cases the grooved cylinder, with a conical grooved point, may prove advantageous.

A few experiments were made to determine the effect of driving spikes to different depths on the total amount of retention. For this purpose two different spikes were selected; viz., the square hand-wrought spike, the section of which was ·405 × ·402, and the wide flat one, of which the section was ·539 × ·288. They were respectively driven to a certain depth into unseasoned chestnut—and then subjected to force just sufficient to start them;—this force was noted, the spike was then driven another inch, and the force applied in like manner. All my experiments prove that when a spike is once started, the force required for its final extraction is much less than that which produced the first movement. This is readily accounted for, on the principle that a wedge-shaped point was from half an inch to an inch in length, and as this on the starting back of the spike a very little distance became mostly relieved from the pressure of the fibres, all that part of the retention which had been due to the wedge-shaped portion was at once destroyed. The following table will show that the mere starting of the spike, with parallel faces, does not essentially diminish the retention, when again driven into the timber to a greater depth than before.

But when a bar of iron is spiked upon wood, if the spike be driven down until the bar compresses the wood to a great degree, the recoil of the latter may become so great as to start back the spike a short distance after the last blow has been given. In this case a great diminution in the useful effect will be the consequence. This shows that a limit may exist to the force which we should apply in urging down spikes or bolts, especially those with large heads, destined to fasten materials together.

TABLE IV.—Spikes driven to different Depths.

No. of the Exp.	Kind of Spike used.	Kind and Condition of the Timber.	Breadth of the Spike, in Inches.	Thickness of the Spike, in Inches.	Area of the Faces in square Inches.	Depth to which driven, in Inches.	Weight in Grains of the part inserted.	Force to extract the Spike, in lbs. Avoirdupois.	Ratio of the extracting Force to weight of Spike.	Remarks.
1	Square not not filed.	Chestnut, unseasoned.	·405	·402	·7695	1·9	483	1183	2·428	$\frac{\text{Retention}}{\text{area of faces}}=770$
2	Do.	Do.	Do.	Do.	1·1745	2·9	789	1995	2·528	Do. =850
3	Do.	Do.	Do.	Do.	·1579	3·9	1095	2565	2·342	Do. =795
4	Broad flat.	Do.	·539	·288	·9702	1·8	442	1525	3·457	Do. =785
5	Do.	Do.	Do.	Do.	1·5092	2·8	745	2594	3·482	Do. =865
										Mean 813

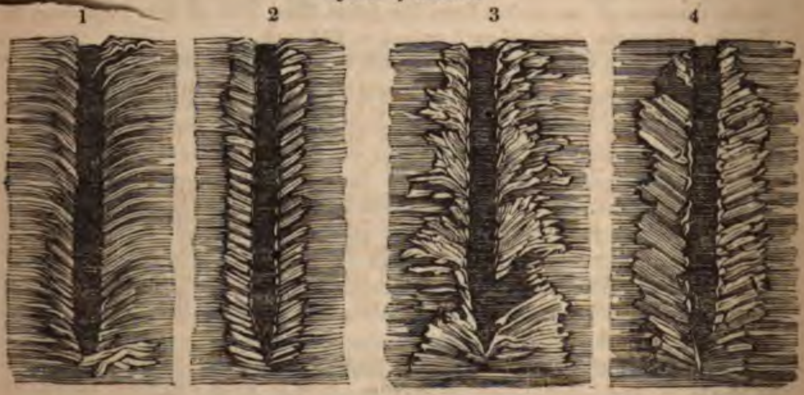
By comparing experiments 1 and 4 together, it will be found that, *weight for weight*, the flat spike had, when driven 1·8 inches, an advantage of 42·3 per cent. over the square one; and by like comparison of experiments 2 and 5, it is evident the former had a superiority of 37·7 per cent. As the spike when driven in only 1·9 inches had a much less proportion of its parallel faces, and a greater proportion of the wedge-shaped point, exposed to the reaction of the fibres, it is reasonable to expect that the retention would not correspond precisely with the lengths inserted. It will be understood that when we speak of cutting edges and the wedge-shaped portion of spikes, whether square, flat, or cylindrical, the direction of the cutting edges is always across the fibre or grain of the timber. It must be evident that the wedge-shaped part may be so acute as to correspond nearly with two parallel faces, in which case, the tendency to retreat from the lateral pressures is small, and the pressures themselves increasing from the point upwards to where the spike is thickest, the total efficiency of a given length may be as great as that of an equal length of the parallel faces, and even greater, provided the thickness of the spike be so great as in driving it to produce much crushing and irregular folding of the fibres of the timber. If, on the contrary, the edge be very blunt, the tendency to recoil may be such as to diminish the adhesion; and in this case, the effect of the wedge-shape is negative. In the other it may be positive*. The 1st, 2d, and 3d experiments indicate, in the 10th column of the preceding table, that beyond a certain limit the ratio of weight of metal to extracting force begins to diminish, showing that it would be more economical to increase the number rather than the length of spikes for producing a given effect in fastening materials together. In this case also it will be perceived, that the adhesion has a much closer relation to the areas of the compressing faces of the spikes than to their weights. The 12th column shows that for three of the experiments this ratio may be regarded as *identical*, and the whole set goes to prove that the absolute retaining power of unseasoned chestnut on square or flat spikes of from two to four inches in length, is a little more than 800 lbs. for every square inch of their two faces which condense longitudinally the fibres of the timber.

The accompanying figures represent the appearances of timber as developed by splitting the specimens, through the axis of the cavities left by the spikes when withdrawn:

Fig. 1—Is that presented by the locust timber, mentioned in Table II., Experiment 11, in which the weight required to extract the spike was 3990 lbs. The upper part of the figure exhibits the rising up of the timber just as the spike starts. In every case this effect was found, on examining the timber, to have been of very limited extent.

Fig. 2—Represents the grain of chestnut timber as affected in Experiment 3, Table III., with the broad flat spike, and other trials. At the point of inflection downward the grain appears to be not only bent but often actually broken off.

Figures of Timber.



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* The following formula may represent the several experiments. $R = lf \pm c$, in which R is the observed retention; $l =$ the length in inches of the part inserted; $f =$ the force of retention on one inch of the parallel sides; and $c =$ the difference between the retention of a parallel portion of the spike and of an equal length of the converging faces near the point. The sign of ambiguity is due to the cause above stated.

Fig. 3.—Exhibits the appearance of a specimen of hemlock timber, used in experiment with the straight grooved spike (Fig. 4 of spikes), in which the weight required to extract it was but 1296 lbs.—See Table II., Experiment 8th.

Fig. 4—Conveys an idea of the manner in which a defective specimen of pitch pine was affected by a spike. The force required to draw this spike was so trifling that it was not thought worth recording in the tables.

Figures of Spikes.

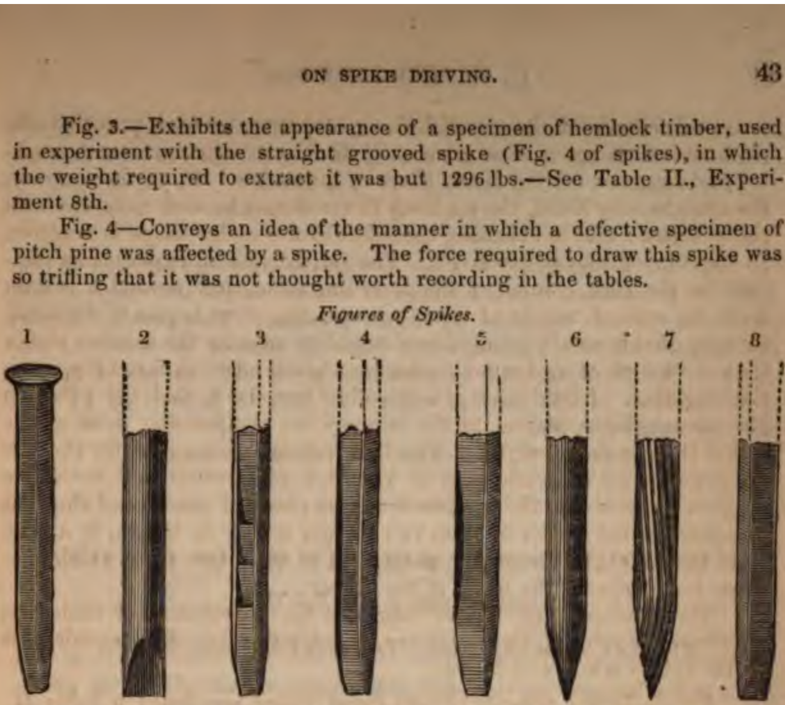

Fig. 1—Is a square spike ·405 of an inch wide on each face, referred to in Table III., Experiments 1, 5, and 13.

Fig. 2—Is a cylindrical spike ·485 inch in diameter, sharpened to a cutting edge.—See Table III., Experiment 9.

Fig. 3—Is the grooved and notched spike, serrated in the bottoms of the grooves on the two faces.—Table III., Experiment 12.

Fig. 4—Is a spike with plain grooves on the faces, extending from the upper part of the bevel to the height of about 3½ inches.

Fig. 5—Is a grooved and swelled spike, that is, having the groove deeper at the distance of two inches from the point, than it is at one inch from it. At the former the depth of each groove is ·066 inch.

Fig. 6—Is a cylindrical spike ·5 inch in diameter, tapered to the point.

Fig. 7—Is a spike of the same diameter as the preceding, but having 15 spiral grooves proceeding from the point upward.

Fig. 8—Is a flat spike ·390 inch in breadth, and ·253 inch in thickness. See Table III., Experiments 4, 7, and 15.

Note.—The only series of experiments, analogous to those above detailed, which has fallen under the notice of the writer, was made in 1824*, by Mr. B. Bevan, on the adhesion of sprigs, brads, and nails, when driven into timber longitudinally and transversely. His operations were extended to several kinds of timber, *viz.* Norway deal, dry oak, elm, dry beech, and green sycamore.

He employed some nails of a very minute size, of which 4560 were required to make a pound avoirdupois. One of these required 22 lbs. to extract it, when driven ·4 of an inch into pine board. From this size he advanced by several gradations to the sixpenny wrought nail, of which 73 make a pound avoirdupois. Of the latter he drove one to the depth of one inch successively into pine, elm, dry oak, dry beech, and green sycamore, and found the forces required for its extraction to be as follows:

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* See Gill's Technical Repository, Vol. V., p. 246.

For Pine	187 lbs.	For Beech	667 lbs.
Elm	327	Sycamore	312
Oak	507		

Mr. Bevan examined, to some extent, the difference between driving a nail by percussion, with a hammer of known weight and range of fall, and forcing it into the wood by simple pressure. This curious inquiry did not, for obvious reasons, enter into the plan of the writer of this article. Mr. B. found, that to force a sixpenny nail into pine 1 inch, it took a pressure of 235 lbs.; to extract it, 187; to force it in 1½ inch, 400; to extract it 327.

[Professor W. R. Johnson, in *The Franklin Journal.*]

ECONOMICAL USES OF SOME SPECIES OF TESTACEA.

[Continued from p. 462, Vol. III.]

II. Mya Margaritifera, (Linn.)—*The Horse Muscle.*

Next to the last species, this shell is the most celebrated for its pearls, and which in old times not unfrequently came into competition with those from India. Julius Cæsar is said to have been stimulated to the invasion of Britain by the sight of the pearls brought from it*; and he certainly on his return to Rome presented a breast-plate made of them to the Temple of Venus Genitrix†. They appear to have been at that time, A. D. 14, an object of commerce to Gaul, if not further south‡. Forty years later they were common in Rome. Pliny informs us they were used in his time, and though of inferior worth, were often so large and beautiful as to be of considerable value. In general, however, they were small, dim, and wanting in lustre.

About the year 1120, the Scotch pearls were in great request. King Alexander I. is said to have exceeded all men in that species of riches, and his pearls, on account of their large size and superior brightness, were celebrated and coveted in distant countries§. In 1355, they were still an article of exportation. They were esteemed in France, but not equally with those of India, as appears by the MS. statutes of the Goldsmiths' Company at Paris, where it is ordained that no worker in gold or silver shall set any Scottish pearls among the oriental ones, except in large jewellery for churches‖, for which, probably, a sufficient quantity of the oriental pearls could not be obtained, or were too expensive.

Among the articles exported to Antwerp from Scotland in 1560, and enumerated by *Guicciardini*, we find "fine large pearls" mentioned¶. In 1665, they were still sought for and worn in England, and a writer in the Philosophical Transactions of London at that time, makes mention of one found in Ireland which weighed fifty-six carats, and was valued at 40*l*., and of another for which 80*l*. had been refused, besides "a vast number of fair, merchantable pearls, too good for the apothecary," offered for sale by persons from the same place*. About 1760, the wearing of real pearls coming more into fashion, those of Scotland, which had previously been almost neglected, increased in price greatly beyond their value, and superior often to the price of oriental ones when bought in the East†. At present we are not aware that they are sought for, except as curiosities.

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* *Sueton. Vit. Jul. Cæs.*, cap. lxiv.
† *Plin. Hist. Nat.*, lib. ix. 35.
‡ *Macpherson*, I. 133.
§ *Macpherson*, I. 318.
‖ Ibid., I. 555.
¶ Ibid., II. 131.

Natural History.—This shell is common to most of the rivers of Europe, but is chiefly found in those which are violent and rapid, and in the temperate or colder climates. In Norway and Sweden they abound, and they are found plentiful in the streams of Western Siberia‡. In Great Britain they are common in the English, Welsh, and Scotch, and some of the Irish rivers; in all which the fisheries were formerly prosecuted. The same opinion as to the formation of the pearls in these was held, as with respect to the last species; and the supposition, that they were formed of dew, or of eggs which had not been evacuated, was supported by scientific writers as late as the seventeenth century.

In 1761 Linnæus informed the King and council of Sweden that he had discovered an art by which muscles might be made to produce pearls, and he offered to disclose the method for the benefit of the kingdom. This, however, was not done, but he disposed of the secret for about five hundred ducats to a German. At the death of this man it was offered for sale, sealed up to the highest bidder, but what became of it is not known. Linnæus once showed Beekman a small box filled with pearls, and said, "*Hos uniones confeci artificio meo, sunt tantum quinque annorum, et tamen tam magni;*" and he declared that he could succeed in the same manner with all kinds of muscles§. They lie in the mud, generally sticking up in a horizontal position by one end.

Fisheries.—Lying generally in shallow water, little exertion or skill is necessary in procuring them, and the business was probably never sufficiently extended or valuable to cause either their cultivation or particular protection. The manner practised in procuring them in the north of Ireland, in 1660, is described in the *Philosophical Transactions*, and exhibits neither art, nor much intelligence. In the warm months before the harvest, while the rivers were low and clear, the poor people waded into the water, and some with their toes, some with wooden tongs, and others with a sharpened stick, thrust into the open shell, brought them to the surface; and although by common estimate, not above one shell in one hundred might have a pearl, and of these pearls, not above one in one hundred might be round and clear, yet sufficient were found to remunerate those who sought for them. "The natives, though very foul eaters, will not eat the fish." The shells which contain the best pearls are wrinkled, twisted, and bunched, and not smooth and equal, as those that have none; and "the fishermen will guess so well by the shell, that though watched never so closely, they will open such shells under water, and conceal the pearl in their mouths or otherwise." They do not appear to have been laid in heaps to rot as the muscle is, but opened, and the gem extracted immediately *.

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* *Phil. Trans. of the Royal Society*, II. 831.

† *Macpherson*, III. 419. *Bruce*, VII. 321.

‡ *Cochrane's Pedestrian Tour.*

§ *Beekman*, II. 5—11.

The following ingenious mode of catching them was practised about fifty years since, in the river Teith, county of Perth, Scotland, and we may remark, that it is the only instance we can meet with, where any skill or invention is obvious in the manner of fishing for them. A kind of spear was made use of, which was shod at the point with iron spoons, having their mouths inverted. The handles were long, elastic, and joined at the extremity, which was formed into a socket to receive the shaft. With this machine in his hand by way of a staff, the fisher, being often up to his chin in water, groped with his feet for the muscles, which are fixed in the mud and sand by one end. He pressed down these iron spoons upon the point, so that by the spring in the handles they opened to receive the muscle, held it fast, and pulled it up to the surface of the water †. It was customary at one time for the Crown to grant patents for the privilege of fishing for pearls in particular streams. Sir John Hawkins held a patent of this sort, and in 1633, one which had been granted to Robert Buchan, of Auchmacoy, in the county of Aberdeen, was repealed by Charles the First ‡. There were also some fisheries in Saxony, which were monopolized by the government, but whether productive or not, we are not informed. They are called by the Welsh, *Cregin Diluw*, or deluge shells, as if they had been left there by the flood §.

III. PINNA ROTUNDATA? (Linn.)

BEFORE the introduction of the silk-worm into Europe from the East, this shell was of much importance in the arts. The only silk of any value, or in any quantity, that could then be obtained, was procured from it, and it was only gradually that it gave way before the cheaper and more beautiful fabric. The animals inhabiting the Pinnæ have the power of fixing themselves to any substance, by throwing out an extensile member, and discharging from its tip a drop of gluten, which, by the retraction of the same organ, is formed into a silky filament, and by frequently repeating this operation a thick tuft is formed, by which the shell is fastened in any situation the animal chooses ||. It is of these silky filaments, which are of a rich gold-colour, that cloth was made; and of such value was it, that for a long time none but monarchs and persons of high rank wore it, as their robes of state.

There have been endless disputes among commentators, what material was meant among the Greeks and Romans by the word, *Byssus*, and they have not unfrequently confounded the *Byssinum*, the *Bombicina*, and the *Sericum* of the ancients altogether as one. Some have supposed the *Byssinum* to be cotton, some make it the same with the *Sericum*, and others, very fine linen. The fact, however, seems to be, that the word was frequently applied indiscriminately to any texture finer than woollen; but on speaking appropriately, it was used solely for

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* *Phil. Trans.*, II. 831.

† *Sinclair's Statistical History of Scotland*, XI. 600.

‡ *Sinclair*, IV. 423.

§ *Pennant's British Zoology, in loco.*

|| *Dillwyn*, III. 24.

the stuff manufactured from the produce of the Pinna[*]. It was in use during the earliest periods, as we find David[†], B.C. 1043, clothed with a robe of it, and we can trace it as an article of commerce until near the end of the fourteenth century. The Hebrew word is *Butz*, but is in general erroneously translated, and in our version of the Bible is confounded with real linen and cotton, under the name of "fine linen." It does not appear in the text of Moses; and the only books in which it occurs are Chronicles, Ezekiel[‡], and Esther[§]. In Chronicles we see David with a mantle of *Butz*, with the singers and the Levites. Solomon used it in the veils of the temple and sanctuary[‖]. Ahasuerus' tents were upheld by cords of it; and Mordecai was clothed with a mantle of purple and *Butz*, when king Ahasuerus honoured him with the first employment in his kingdom, about B.C. 509. It was among the merchandise imported into Tyre from Syria, enumerated by Ezekiel, B.C. 588. Lastly, it is to be observed that there was a manufactory of this article in the city of Beersheba, in Palestine[¶].

The *Butz* must have been different from common linen, since, in the same place where it is said David wore a mantle of Byssus, we read likewise he wore a linen ephod. Herodotus (B.C. 450) says, that the bodies of rich persons in Egypt were wrapped in bandages of it, after being embalmed[**]. In the time of Pliny, the Roman ladies were particularly fond of it, and would buy it for its weight in gold[††]. In the New Testament the word frequently occurs, where it is translated the same as in the Old, but always indicating riches and splendour[‡‡].

In later times, it was chiefly brought from India, Egypt, and Elis in Achaia, and some apparently from the coast of Judea. In 1265 it was imported from Asia into England[§§], and in 1830 we find five bales of it mentioned, in the catalogue of the cargo of a ship bound from Genoa to Bruges in Flanders, and which was driven ashore on the English coast[‖‖].

It is still manufactured at Palermo, into gloves and other small articles[¶¶]. It is also used at Taranto, (the ancient Tarentum,) where it is called *lana pesce*, or *lana penna*. Having been cleaned, combed, carded and spun, it is finally knit into stockings and gloves of a soft and extremely warm texture, and of a beautifully glossy brown colour, enriched with a golden hue. They are reckoned excellent preservatives against cold and damp, but the price renders the article more an object of luxury and curiosity than of general utility[***]. To spin this Byssus they leave it some days in a damp cellar, to moisten and grow soft; after this they comb it to get out its impurities, and lastly spin it as they do silk;

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[*] "‘Αι δε πινναι ὀρθαιφυονται ἐκ βύσσου ἐν τοις ἀμμωθεσι και βορβορωδεσιν;" and Duval in explanation adds, "*ex bysso, id est, villo, sive lana illa pinnali.*"—*Aristotle, Oper. omnia.* Paris, MDCXXIX; tom. II. p. 844.

[†] 1 Chron. xv. 27.

[‡] Ezek. xxvii. 16.

[§] Esther i. 6. vii, 15.

[‖] 2 Chron. iii. 14.

[¶] See *Calmet's Dict.* Art. BYSSUS.

[**] Σινδόνος βυσσίνης. *Herod.* lib. ii. cap. 86. Compare also the Greek of Luke xxiii. 53.

[††] *Plin. Hist. Nat.* lib. xix. cap. 1.

[‡‡] Luke xvi. 19. Rev. xviii. 16, &c.

[§§] *Macpherson*, I. 415.

[‖‖] *Ibid.*, V. 590.

[¶¶] *Dillwyn*, III. 24.

[***] Hon. Keppel Craven's *Tour through the southern provinces of the Kingdom of Naples*, p. 185.

and though grossly spun, it appears much finer and more beautiful than wool, and does not come much short of silk itself*. A species of Pinna is much fished for in the Red Sea, as it contains pearls. The inside is of a beautiful red, and the pearls always partake of this colour, while they are generally the darkest as they approach the large end, which is the most brilliant†. Bruce supposes, that from this circumstance, the Hebrew word *Penin*, or, as it is more generally written in the plural, *Penenim*, Pearl, is derived, as the root of it signifies *red*, and that it was from these shells the pearls used in Judea were taken; of course it is impossible to decide, as oriental pearls are also found thus tinged, but it is not improbable ‡.

The derivation of the word *Byssus*—*βύσσος*, is probably *βυσσὸς*, *Ionicè* for *βυθὸς*—depth, as being found in comparatively deep water. The word Pinna has been idly supposed to be derived from the Latin word *penna*, a feather—from an imagined resemblance between the shell and the quill. The Greeks, however, used the word *πινα*, or *πιννα*, and must have derived it from the Hebrews. Bruce asserts, that in the Red Sea they live in the mud without any byssus, sticking up horizontally on the sharp end; he is, however, most probably mistaken. They were the only shell-fish that he found there not eatable.

IV. MYTILUS ———— ? (Linn.)

THERE is another shell in the Red Sea, which is regularly sought after as containing pearls. It is a Mytilus, and appears nearly to resemble the *M. edulis*. It is the rarest kind, and is chiefly found at the north end of the Gulf, and on the Egyptian side. The only place where Bruce ever saw them, was about Cosseir and to the northward of it, where there was an ancient port, which took its name *Myos Hormos*, the *Harbour of Muscles*, from their locality. The fish contain often pearls of great beauty for lustre and shape, but seldom of a white or clear water. They lie in the deepest and stillest water and on the softest bottom, and they stick upright by their extremity§.

V. In Australia we are told of another large pearl-bearing shell, but of what genus we are not able from the accounts to decide. It is the Menangey—occasionally denominated the New Holland cockle, and it produces large and beautiful pearls. Mr. Dalrymple mentions one belonging to Lord Pigot, which weighed 8 dwt. 17 grains, and was $\frac{48}{60}$ inch in length, and $\frac{38}{60}$ inch in diameter||.

(To be continued.)

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* *Rees' Cyclopædia*, Art. BYSSUS.

† *Bruce, ut supra.*

‡ Statius (*Silviæ*, 4, 6, 18.) uses the phrase, '*Erythræus lapillus*,' and some other writers make use of the words, '*Erythrææ gemmæ*,' for pearls, but whether from their red hue, (*ερυθραιος*,) or because they were from the Red Sea, *Erythræum Mare*, is questionable. Pliny says that the pearls from this sea in his time were the most orient and clear.—Plin. ix. 35.

§ *Bruce's Abyssinia*, VII. 314; and VIII. Plate 43.

|| *Burney, Chron. Hist of Disc.* I. 94.

THE NOVEMBER-ASTEROÏDS.

Notice of a recent Communication relating to them, by Dr. Olbers.

Those who take an interest in physical sciences have, within these few years, had their attention directed to the periodical return of shooting-stars; and recent observations go far to subvert the opinions formerly held with respect to them—namely, that they originated within the limits of our atmosphere. On the contrary, it is now looked upon as an established fact, that they are heavenly bodies of inconsiderable dimensions, but which, in common with all others of a similar nature, have, of course, a regular motion. They are, in short, supposed to represent, in the solar system, the animalcules of the animal kingdom.

Olbers, in the *Jahrbuch für* 1837, brings forward, with irresistible force and clearness, numerous proofs in favour of this supposition; and the following general sketch will, it is hoped, give a faithful abstract of the arguments to which he therein has recourse, in favour of the new theory.

On the 12th of November, 1799, before sun-rise, Humboldt and Bonpland, on the coast of Mexico, observed, during four hours, a succession of many thousand shooting-stars and small fire-balls. The part of the heavens whence they emanated lay due east, and they extended over a space of 30° to the right and left of that point. They rose above the horizon in an east-north-east direction, and fell towards the south, describing unequal arcs in their course. Some attained an altitude of 40°, and there were none that did not rise to between 25° and 30°. Several appeared to burst; the largest, however, disappeared, without throwing out any coruscations. Some had a large nucleus equal to Jupiter in brightness, and all, or nearly so, had tails.

This remarkable phenomenon was also simultaneously observed from various distant points of the earth. A similar display was again witnessed on the night of the 13th of November, 1831, on the night of the 12th of November, 1832, on the same night in 1833, and on the night of the 13th of November, 1834.

This periodical return induced many persons, where the cloudy state of the weather did not altogether put a stop to their observations, to keep a good look out on the nights between the 11th and 14th of November, 1836; nor was the trouble they thus took thrown away, for it appears that a vast number of shooting-stars were actually at that time observed from the most distant points of the globe.

The periodical return of these bodies would thus seem to be established, but this is not sufficient for us to form any just notions as to their nature. The first step to be taken to that end is to discover what their elevation above the earth's surface may be.

In order to arrive at this, two observers in concert determine the angle under which they see a shooting-star, indicating likewise the time of its appearance, and noting the star near which it came into sight. Now, if two such observers remark at the same instant, and in the same direction and position, any shooting-star, it may fairly enough be assumed that they are looking at one and the same object. A triangle is thus obtained; the base—that is to say the distance between the observers, and two angles of which, are approximately known, so that the calculation of the distance presents no difficulties whatever.

Simple as these observations are, it is evident that they cannot pretend to anything like exactness; as they are, however, very numerous, their errors are thereby eliminated, and approximate results, at least, are arrived at; and the distance being thus ascertained, their real velocity may be deduced from the apparent.

Olbers conveys his opinions respecting these bodies in the following terms. The remarkable and very unequal distribution of those small bodies revolving round the sun, which form the fire-balls and shooting-stars of our planetary system, as well as the general resemblance and nearly similar nature of all the meteoric stones which fall from time to time (taking into consideration both their external characters, and also their chemical composition), seem to indicate not only that they have one common origin, but also that it was one common cause which has thus hurled them into space.

One cannot help reverting, involuntarily, to the hypothesis which holds the four new planets, Vesta, Juno, Pallas, and Ceres, to be but fragments of a larger planet, formerly revolving round the sun between Mars and Jupiter, but which has been shattered to pieces by some violent catastrophe. On such a planet as this exploding, and being scattered about in all directions, there would also be, independent of the larger fragments, innumerable much smaller, indeed minute pieces, hurled into space, and these would now circulate about the sun in ellipses of various degrees of eccentricity.

It must be borne in mind that Olbers treats this, however, as a mere hypothesis, and distinctly says he by no means adopts the language of Professor Wildt, who, as may be seen by referring to the 9th Volume, p. 408, of *Voigt's Magazin für den neusten Stand der Naturkunde*, unreservedly asserts, the stones which have fallen on the earth to be "the ruins of some globe which has been destroyed, and which revolve round the sun till, sooner or later, they fall in with a planet.

"They without doubt, he continues, belong to the group of Ceres, Pallas, &c., and thus we see how it is that their appearance and composition bear such general resemblance to each other."

What we really know of shooting-stars, of those, at least, which are allied to fire-balls, if not actually identical with them, may be summed up in the following words:—

1st. They move at considerable elevations above the earth, their distances from it ranging from between 140 to 190 miles.

2ndly. Their velocity is equal to that of several of the planets; and their relative velocity, compared with the earth, may vary from 37 to 42 miles in a second*.

3rdly. Hence it is from without the regions of space that they enter our atmosphere, and it is not within the limits of the latter that they originally take their rise.

4thly. They are not ejected into the earth from the moon.

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* Littrow gives the mean velocity of Mercury only at 30 miles per second, that of the earth at 19 miles, and the mean of the four new planets at 12.

Much that is connected with these interesting meteors, it is, however, quite out of our power to explain. For instance, how is it that they become ignited? How is it that, in the extremely rare medium in which they move, they continue glowing, or, indeed, burning with such brilliancy? How can the comparative small mass of the meteoric stones which falls to the earth expand in those elevated regions to bodies several hundred feet in diameter?

Must we not suppose, with the acute Von Hoff, of Gotha, that the materials of which shooting-stars originally consist are submitted to a peculiar chemical process upon entering into our atmosphere, the result of which is the formation of the substance we see fall as meteoric stones, —a process which surely cannot consist merely of fusion?

All these questions, and many others of a similar nature, will possibly remain for ever unanswered, or be, at least, but unsatisfactorily solved; for it scarcely appears probable that time can give us a deeper insight into the circumstances connected with this subject. How can we, indeed, even hope to arrive at a satisfactory knowledge of processes carried on at altitudes where the air is far rarer than in the most perfect vacuum we can produce, and where, moreover, the atmosphere possibly consists of gases of which we know nothing, and all carried on at a temperature of absolute cold. What powers affinity, electricity, and magnetism are there invested with, will always remain a mystery to us.

Munich, 10*th July*, 1837. *Ω.*

ARTIFICIAL PROCESS OF PETRIFACTION.

The idea of petrifaction belongs properly to a comparatively small number of the impressions of wood and stems which we find in all formations, and still more abundantly in boulders at a distance from their original locality, and the term ought always to be so limited.

The vegetation preserved in brown coal often hardly deserves any other term than that of dried vegetable matter; and, in fact, fossil wood often differs but little externally from wood which has lain for a long period in water.

The phenomenon of petrifaction was attempted to be explained at an early period. Agricola* thought that it took place by means of a liquid containing stony matter, which penetrated the spaces of vegetable and animal bodies, and gradually communicated to them a stony character. The later mineralogists, as Scheuchzer, Walch, Schulze, Schröter, Wallerius the elder, agreed in the opinion, that, when a body is petrified, or converted into metal, an exhalation must first proceed from it by which it loses certain particles, in whose room earthy or metallic ones enter, and that thus, at last, the body is converted into stone or metal. The means by which the exhalation is promoted in animals is, according to the same view, calcination, and in plants the reduction to earth.

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* *Lib.* 3, *de ortu et causis subterran.* p. 507; *Lib.* 7, *de natura fossilium*, p. 639.

More recently, so far as is known to me, no one has attempted to trace out this process by an experimental inquiry, it being probably supposed that too long a time would be required for obtaining the desired result. In a lecture* delivered in London by Faraday, at the beginning of 1836, he says, "that we have no knowledge whatsoever of the nature of this process, for the instances of recent fossilization, which have as yet been produced from various places, are mere incrustations of calcareous, or even of siliceous matter, where there has been no preservation of organic forms,—none of that beautiful and incomprehensible *substitution* which, while it exites our admiration, baffles our curiosity." For a long time I was occupied in examining the way which nature had employed in this process. First of all I made the experiment with iron. I introduced plants into a moderately-concentrated solution of sulphate of iron, and left them there until the separation of the salt on the outer portions of the plants showed the sufficient saturation, or I at once soaked smaller portions of plants and sections of wood in the same solution for several days. They were then dried and heated till they no longer suffered alteration of volume, or until every trace of organic matter had disappeared. *On cooling them, I found the oxide thus produced in the form of the plant.* I now took thin vertical sections of the *Pinus sylvestris*, treated them in the same manner, and found them so well preserved after heating *that the punctured vessels peculiar to this family were still perceptible. Just as well preserved were the sporangia of Ferns; the pollen (of Arum Dracunculus, Ricinus communis, &c.;) mosses (Hypnum splendens, intricatum, Fontinalis squamosa); and even Fungi, as Agaricus deliciosus, Clavaria flava, &c.* After these successful experiments, I was desirous to perform others with a solvent of silica. In vain I tried the common solution of silica (*Kieselflüssigkeit.*) For when, after heating, the silica remained in the form of the plants, the mass, as was easily understood, disappeared on being cooled. I obtained a more successful result by dipping in a volatile acid such as the acetic, and before the application of heat, the fragment that had been soaked in a siliceous solution; but still a portion of the silica taken up by the plants was separated, and so irregularly that it became impossible to recognise the structure. *Silico-hydro-fluoric acid*, prepared according to the formula of Berzelius, answered my wishes better, for the fluoric acid was volatilized, and the silica remained in the form of the plant. Similar results were obtained with most of the other earths and metals, and I generally selected combinations whose acids were easily decomposed by heat, as acetate of lime, acetate of magnesia, sulphate of magnesia, which were all converted into carbonates; nitrate of silver, nitrates of gold and platina, which were all converted into reguline metals; acetate of copper, which was converted into brown oxide; acetate of nickel and bichromate of potash into olive-green oxides; acetate of lead into yellow oxide; manganese into metallic shining manganese; cobalt, wolfram, and molybdena into oxides; and all of them retaining more or less the vegetable structure. In proportion as the number of vessels in a plant is greater, and therefore the quantity of cellular tissue less, so much the more perfect are the results obtained in these experiments. In very delicate portions an immersion for a few days is sufficient, and in larger pieces a longer period is requisite; but upon this subject I cannot communicate very exact information, as I only discovered these facts a few weeks ago*.

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* *The Lancet*, February 6, 1836.

In order to ascertain the change undergone by the organs of the plants, I placed the above-mentioned products in water. The potash skeleton, which may be distinctly seen in most plants, is dissolved, and I thought at first that I remarked that only the vessels were filled or injected with metallic or earthy matter, and that their sides were destroyed by the action of the fire. When, however, I experimented in the same way on several plants which contained less alkali, I saw, in company with my much-respected friend Professor Purkinje, that, for example, by immersing in an iron solution the wing-like appendages of the seeds of the *Pinus sylvestris*, *the walls of their peculiar fibre-like formed cells were actually converted into iron;* and that, in the case of a vertical section of the *Pinus sylvestris*, which was soaked in silico-hydro-fluoric acid, the punctured vessels were converted into silica. In those which are changed into reguline metal, we see this phenomena very distinctly if we continue the red heat for only half an hour. By a longer continued action of this degree of heat, the arrangement of the metal is so altered that the connexion of the vessels and cellular tissue is somewhat broken; and now (I cannot suppress the remark, although I do not draw any conclusion from it,) there is a great resemblance to those hair-like forms in which the above-mentioned metals sometimes occur in the native condition. The richer a plant is in potash and cellular tissue, a condition which occurs in herbaceous plants, the less do these experiments succeed. It is true, that after the heating there appears in the form of the plant the earth or the metal which has been employed, but, on pouring water over it, nearly everything is dissolved, and only separate vessels or cells remain behind; as, for example we remark, in the leaves of the ferns. Although these experiments, which also promise much advantage to vegetable physiology, are capable of being carried much farther, yet, when we apply their results, first of all, to the process of petrifaction, we can already understand why *only trees and shrubs occur truly petrified, and never herbaceous plants.* Shrubs occur more rarely than trees, because, though they contain less potash than herbaceous plants, yet when calcined they yield more than trees. If we proceed in this way, we shall in future possess in chemistry an important and serviceable assistance for the determination of fossil plants, as we shall be authorized, by the experiments detailed above, to declare, with certainty, that plants rich in potash can never be petrified: an assumption we are so much the more entitled to adopt, since the experiment with the fossil fern proves, how, in this respect, the vegetation of the ancient world corresponds with the vegetation in the present day. I intend to examine in this manner the most important families of the vegetable kingdom; and I hope, by means of this synthetical method, to attain many desirable conclusions regarding the analogy of many yet doubtful natives of the ancient world.

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* I for the first time made public this discovery on the 6th of July (1836), at the meeting of the Natural History Section of the Silesian Society.

Animal bodies, as dry fibrous muscles, can also be altered in this manner, but whether they can be converted into another substance I do not venture to assert; but the experiment succeeds with insects, as with flies, gnats, (whose more delicate parts, the wings and feelers, are well preserved,) the muscles of crabs, and also with infusory animals. Thus I saw quite distinctly a species of Daphnia (from the half putrid water of a water-barrel) which had been placed in a solution of iron, become converted into iron after being exposed to a red heat for half an hour, and even its feet were thus changed. If, then, we were to place infusory animals, whose skeletons did not consist of silica, in a siliceous solution, and then heat them to a red heat, we might be able to form artificially *Bergmehl*, tripoli, and polishing slate, whose composition has recently been unfolded by the extremely important discovery of Ehrenberg. Evidently here, also, the larger or smaller quantity contained by the animal organs of solid materials insoluble in water (viz. phosphate of lime), would exercise great influence on the success of the experiment. In the parts richly provided with fat, that substance would oppose insuperable obstacles to the preservation of the form, for during the heating it would swell out, and change the whole into a formless mass. I intend to prosecute also these experiments; and, in the mean time, we may, perhaps, regard the last-mentioned circumstance as the reason that animals of a higher class cannot be petrified.

The experiments now communicated seem to me to throw an important light on the process of petrifaction. We may assert, with safety, that the first act began with impregnation, and that then the organic matter was removed either by a high temperature, or by the moist method, or by a gradual decay. The last seems to me by much the most probable, and hence also the greater compactness of fossil wood may be explained, a topic which, owing to the extensive range of the whole subject, and the short time devoted to it, I did not reach. Although nature certainly did not employ the acids which I used, in her formation of the woods converted into flint or calcedony, yet the possibility of imitation has here been proved, and we may hope that yet further elucidation of the subject may be attained by other means*. But, before succeeding, I will not speak of the attempts which I have already commenced to reach the desired object. In conclusion, I have to remark, that specimens have been sent of the imitations of organic remains to the collections of Berlin and Breslau. — GÖPPERT. *Poggendorff's Annalen.*

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* In a more-recently published notice, Hr. Göppert remarks, "By placing plants for some time in silico-hydro-fluoric acid, I succeeded in obtaining a coating of calcedony, which was perfectly clear and transparent, and resembled hyalite. I made this observation at the beginning of August, and shewed the result of the experiment to several friends."

THE BAROMETER.

III.—ON THE RELATION BETWEEN THE BAROMETER AND VARIOUS METEOROLOGICAL AGENTS.

[Concluded from Vol. III., page 416.]

HAVING treated on the contrivances for noting the amount of change in the pressure of the atmosphere, we will state some of the causes which produce such endless fluctuations therein.

If we take 14½ pounds as the average atmospheric pressure on a square inch at the earth's surface, any diminution of that quantity must arise from a diminution in the number of aërial particles in a given space, that being our idea of the word *expansion*. Now this is brought about mainly by heat; the solar rays heat the air in passing through it, and likewise by being reflected from the earth's surface; but as the latter heating process is much more efficient than the former, the lower strata of the atmosphere become more heated than the upper, the consequent expansion renders it specifically lighter than that next above it, and, by virtue of that rarity, ascends to a more rarefied stratum. Now, if every part of the globe shared equally and simultaneously the sun's rays, the same formation and ascension of expanded and lightened air would take place at every part; during the day, the whole atmosphere would be rarefied, reach to a greater height above the earth, and, as night came on, the whole would be gradually condensed again, and fall nearer the earth, and these reciprocating changes would occur every day.

But as it is, the sun's rays being vertical but at one spot at a time, and more and more oblique as we recede from that spot, every gradation of temperature is experienced from 120° above, to 50° below, zero. Now, let us suppose two belts on the earth's surface, one situated vertically under the sun's path, and the other receiving his rays obliquely, and therefore with less heating effect: the air in the first belt is more expanded by heat than that in the other, greater rarefaction exists in the one than the other, and as gaseous as well as aqueous fluids always tend to an equality in density, the air in the colder belt rushes towards the warmer.

This motion is the grand and prolific source of *wind:* the equatorial regions being constantly more heated than the polar, a constant current of cold condensed air is flowing from the latter to the former, to fill up the partial vacuum occasioned by the greater expansion and rarity of the air at that point. It might be supposed that, as the equatorial belt contains not only its own air, but is constantly receiving fresh accessions from the polar region, an overpowering weight of air would accumulate at that part; but this is prevented by a counter-current in the higher regions of the atmosphere. An elevated stream of warm air is constantly flowing from the equator towards the poles, to supply the place of that which flows from the latter towards the former near the earth's surface.

This rush of air from the poles to the equator would engender a constant north wind in the northern hemisphere, and a constant south wind in the southern hemisphere; and the circumstance that we do not find it so is no proof of the incorrectness of the conclusion, for such would be the case, if the earth did not revolve on its axis; but that revolution changes the direction of the stream of air thus:—The atmosphere revolves with the earth, and as every part of the earth's surface revolves round the axis once in 24 hours, the parts nearer the pole must obviously describe a smaller circle than those at the equator, and therefore move with a less velocity; and as the atmosphere shares the velocity of the part of the earth over which it is vertical, the polar and temperate portions move more slowly round the axis than the equatorial portion. The stream of cold air, therefore, which rushes to the equatorial regions, is a slow-moving zone, the transverse approach of which towards the zone moving more quickly gives it the effect of an *oblique* approach, and it is consequently found that north of the equator there is a wind (or stream of air) constantly coming from the north-east to the equator, and at the south of it a south-east wind blowing towards the same boundary. These winds, from the dependence which may be placed upon them, and from their consequent value to navigation, are called the *trade-winds*, and extend about 30° on each side of the equator*.

These winds, however, maintain their regularity only in the open ocean; where land breaks the continuity of liquid surface, great changes are produced, but the most remarkable effects exist in the Indian Ocean.

If we draw a line from the Cape of Good Hope, in Africa, to Swan River, in Australia, we should there have the extreme southern boundary of the trade winds; and were no interruption offered by the neighbouring continents, the south-east trade-wind would extend northward to the parallel of Zanguebar, in Africa, and Sumatra, in the Indian Archipelago, north of which line would blow the north-east trade-wind; but a remarkable change is effected, which shows itself thus:—the 3rd degree of south latitude is a boundary between distinct winds; from that boundary northward to the continent of Hindostan, a north-east wind blows from October to April, and a south-west from April to October; while from the same boundary to the 10th degree of south latitude, a north-west wind blows from October to April, and a south-east from April to October. These winds are called *monsoons* (a Malayan term for "seasons"), and are supposed to originate thus:—It will be observed that the northern monsoon corresponds with the northern trade-wind during the northern summer, and the southern monsoon with the southern trade-wind during the southern summer. It therefore appears that the sun's presence exerts great influence on them, and the proportional distribution of land and water suggests the following considerations:—Water, from its transparency, admits more rays of light and heat to pass through it than it reflects from its surface; but with solid ground it is just the reverse. During our northern summer, therefore, the sandy plains of India (which are wholly within the northern hemisphere) become greatly heated, and expand and rarefy the air over them more than that which hovers over the ocean, the consequence of which is, that a stream of cold air flows from the sea towards the land; but when, at the end of September, the sun passes the equator and enters the southern hemisphere, India gradually loses its excessive heat, and the land and sea becoming more equable, the north-east trade-wind resumes its usual course.

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* It has been generally supposed that the trade-winds are more easterly, the nearer we approach the equator; but Captain Basil Hall has ascertained the contrary to be the fact, and has well explained it by referring to the figure of the earth. The 20th parallel of latitude, for instance, does not differ from the equator in circuit so much as the 40th differs from the 20th, and thus the retardation which gives the easterly tendency is not so great near the equator as at a further distance.

But now the southern suffers a similar change; the vast continent of Australia, which is wholly within the southern hemisphere, exerts the same disturbing force on the south-east trade-wind as the hot plains of India did six months previously on the northern.

Europe is too remote from those regions to share much of these effects, but they are important to our purpose as showing the vast influence which the relative distribution of land and water has upon the equilibrium of the atmosphere. Thus, on sea coasts in warm climates, a breeze is blowing towards the land during the day, and *from* the land during the night. This arises from the circumstance that the sea suffers but little change of temperature during the 24 hours, being generally colder than the land during the day, and warmer during the night: this determines the relative expansion of the air over each, and the consequent direction of the wind.

These are the only circumstances under which the direction of a wind can be depended on with tolerable accuracy. The "fickleness of the wind" has become a proverb, and we are yet unable to fix the causes of the changes in the temperate winds. There appears, however, to be *a general* tendency towards south-west winds in the northern hemisphere, and north-west in the southern; this probably arises from the upper currents flowing from the warm to the colder regions; they approach the earth gradually as they proceed, and thus come to be considered as the prevailing winds.

The aspect of a country, with respect to mountain-chains, &c. is very influential on winds, thus:—supposing a general south-west wind to blow from the ocean to a country which had a chain of mountains running from north-west to south-east; the northern part of that country might scarcely feel the effects of the wind in question, from the intervention of the mountain-range. And thus, likewise, in a smaller degree, every change in the elevation of the country exerts an influence on the direction and intensity of the wind.

The tendency to the equalization of density and of heat in the atmosphere happily subdues in some measure the extreme cold of the frigid and the scorching heat of the torrid zones, but still a necessarily warmer state of the atmosphere constantly exists at and near the equator than at any other part; and this brings us to another important branch of our subject—the increased capacity of air for aqueous vapour at a higher temperature. In what way heat insinuates itself between the particles of bodies is uncertain, but the effect is the separation of those particles further asunder. It has been stated that when a fluid is heated, evaporation is gradually increased; but its free and rapid escape in the manner which we call boiling, depends altogether on the amount of *steam* pressure contained in the atmosphere. At the usual state of the air, water boils at 212°—in a vacuum at 72°; and by greatly condensing the pressure on its surface, 400 degrees have been attained before boiling commenced.

This being the direct effect of heat, then, we can easily understand that the great bodies of water in hot climates are constantly sending forth accessions to the atmosphere, in the shape of aqueous vapour; it is thus that the immense basin of the Mediterranean is believed to maintain a constant level; the mighty bodies of water which the Nile and the great European rivers pour into its bosom, would overflow its shores, were it not for this slow but constant evaporation, as it has been found that no current flows through the straits of Gibraltar from the Mediterranean to the Atlantic; on the contrary, a current flows in the opposite direction.

The same takes place to a smaller extent in other climates, and hence arises the question, "What becomes of this body of aqueous vapour?" It is wafted, together with the warm air by which it is surrounded, to colder regions, and these becoming condensed, have no longer the rarity or tenuity requisite to retain the invisible aërial form. When its cold, from any sudden change of elevation or of density, is increased, it falls to the earth as rain, snow, or hail, according to the temperature of the space through which it has to fall. It is thus conjectured that the overflowing of the Nile is brought about; the great evaporation from the Mediterranean and Red Sea is carried by wind into central Africa, and there meeting with the elevated Mountains of the Moon in Abyssinia, the clouds are condensed into water by contact with the cold summits, and descend in a sheet of rain such as Europe is never subjected to, and thus the sources of the Nile, after the hot season, become enormously distended.

Now the winds of the Indian Ocean, and the rains of central Africa, being copied in miniature at every part of the earth, we need no longer wonder at the constant variation in the pressure of the atmosphere which supports the mercurial column in the barometer. Should a body of air, highly saturated with aqueous vapour, be from any cause removed to a colder altitude, its steam becomes precipitated into the form of cloud, and ultimately of rain, and an immediate disturbance of the equilibrium of the atmosphere is the result, which is followed by a variation in the height of the barometer.

But we must here be understood as not affirming that the rise or fall of the barometric mercury is an exact index of the varying proportion of the aqueous vapour contained in the atmosphere. The sources of the increased pressure are various, and difficult to assign with precision; for instance, it has been found at Paris, by many thousand accurate observations, that the mercury stands higher at that place during a north-east wind than during any other, and lowest during a north-west; that it is higher at nine in the evening than at three in the afternoon, and still higher at nine in the morning; that it is higher in February and lower in October than in any other months of the year: we must, therefore, guard against supposing that the hottest month, or the hottest time of the day (although it may give the greatest amount of evaporation,) will give the minimum of pressure*.

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* The influence which common parlance exerts on the acquisition of correct notions on scientific subjects, has often an unfortunate tendency. Thus, when we say in dull weather, "the day is heavy,"—"the air is thick and heavy," it is not generally supposed that the air is really *lighter* than on a fine day; but the fall of the barometer indicates the fact.

Few subjects have led to more theories than the production of rain. Many have believed that it results almost wholly from electrical causes. This idea is supported by observations made in various ways upon the electrical states of clouds and rain. Dr. Hutton's ingenious theory is grounded on the increased capacity of heat for aqueous vapour at a higher temperature; but that that capacity does not increase in the same ratio as the temperature of the air increases; for example: the capacity for aqueous vapour of a body of air at 55° Fahr., is not a mean between the capacity at 50° and at 60°, but is somewhat *lower* than the mean.

Again, aqueous vapour at 40° has an elastic tension of 0·263 inches, and at 60° a tension of 0·524. If, therefore, two masses of air—the one at 40° and the other at 60°—being both saturated with moisture, are mixed together, the compound will take a mean temperature of 50°; but the tension of steam at 50° is 0·375, while the mean of the forces at 40° and 60° is 0·393. The tension is therefore greater than the temperature can contend against, and a portion becomes condensed in the form of rain.—[*Encyc. Met.* Art. METEOROLOGY.]

There is a mysterious and powerful agent in atmospheric results, to which we have just alluded, viz. electricity. It is not our intention to enter fully into electric science: we may state, that the principal atmospheric effects produced through electrical agency depend on the simple circumstance, that the aqueous particles found in the atmosphere do conduct electricity, while its constituent gases do not conduct electricity.

In electricity, we are accustomed to say that the dry air is an insulator, or that if an electrified body be surrounded by dry air, the electric charge will not leave it. Now, this expression, *dry air*, simply means air deprived of the *steam-atmosphere*, and though that we can *never* get, yet the finer and warmer the weather, the more expanded is this atmosphere, and the less liable to appear in the watery form, so that there is reason to believe that if the steam-atmosphere could maintain a high temperature, and a consequent high tension, it would have the insulating properties of the dry gases, for electrical experiments succeed exactly in proportion to the *warmth* and dryness of the apartment in which they are conducted; while in a damp, misty day, where the steam-atmosphere may be almost said to be in the transition-state from air to water, the failure of the same experiments is an almost certain consequence.

What are the conditions of equilibrium in the electrical state of the atmosphere, are not yet determined; but it is found that that equilibrium seldom exists in a complete degree. If a kite be elevated into the air, through the string of which a metallic wire passes, connected at the lower extremity with an electroscope, it is generally found, even in the finest weather, that the latter is slightly affected, thus indicating the non-existence of electric equilibrium in the stratum of air in which the kite is situated; this indication becomes stronger, as the kite is more elevated, and generally denotes *positive* electricity in the air—indeed, invariably so in fine weather; it is stronger in winter than in summer, and in the forenoon than in any other part of the day.

When, however, the atmosphere is cloudy, and the clouds appear to be moving about in different directions and in an uncertain manner, the electric excitation is much increased, and changes from positive to negative, and *vice versâ*, with great frequency. The *negative* state is prevalent on the approach of any phenomenon connected with the condensation of aqueous vapour into the watery form, such as rain, hail, sleet, snow, fog, &c. This is followed by frequent alternation from positive to negative, which alternation rapidly increases if a thunder-storm be forthcoming.

It is not improbable that the carbonic acid atmosphere to which we have before alluded, has great influence on the determination of the condition or kind of electricity which is manifest at any given part of the atmosphere; for if a room be filled with the respired breath of several persons, it is in a state of *negative* electricity.

Setting aside for a moment the effect of the amount of vapour in the air, it is found that in proportion as the latter is rarefied, the conducting power which it exerts on electricity is increased; and we can from this understand how much the variations in density which are produced in the air by causes already mentioned, are likely to disturb the electrical equilibrium of its particles. This disturbance, by causing the rapid transfer of electricity from large masses of air which are over-saturated with it, to others which have less than their proper amount, condenses the air in some parts more than the other, and by varying its pressure, causes fluctuations in the mercurial height of the barometer.

It will thus be seen that temperature, electrical equilibrium, retention or deposition of aqueous vapour, elevation of position, and various other considerations, take part in the determination of the height of the barometric mercury; but, as was before observed, the relative proportions in which these elements are concerned in the production of any given state of the atmosphere, we have not, in the present state of our knowledge, the means of deciding: but the average of a large number of observations made by different persons, at different times, and in different places, have furnished rules which deserve *some* degree of reliance, although far from implicit.

A fall in the mercury generally indicates approaching rain, snow, high winds, or thunder; a very high wind, whether accompanied by rain or not, is, perhaps, connected with the lowest state of the mercury: in the temperate latitudes, the rise and fall is more extensive than near the poles, or near the equator: in England, as well as in France, a north-east wind is more conducive to a high state of the barometer than any other.

When the mercury either rises or falls pretty steadily for two or three days together, it is generally found that rather a long continuance of settled weather will follow—rainy in the former case, and fine and dry in the latter: by the same rule, frequent fluctuations in its height are found incompatible with an equable state of the weather.

Such are the principal rules for observation; but the dependence which is commonly placed on the wheel barometer, or weather-glass, is much more than it deserves; the dial on which the index moves is graduated into a number of divisions, and at different parts of those, the words " set fair," " rain," " much rain," &c., are engraved: now, the phenomenon of rain does not depend on a given, *fixed*, pressure of the air, but on comparative *changes* which occur in that pressure; when, therefore, we see at a certain number of inches, and hundredths of an inch, the words "much rain," we might conclude that as long as the index were at that part, rain would fall, while at the height marked "set fair," rain could not possibly occur: this, however, is not found to be the case; and a vague and general power of prophecy is all that can be obtained by this form of the instrument.

A Torricellian barometer, however, well constructed, is applicable to much more valuable purposes than the common weather-glass;—we now proceed to notice one; viz., the admeasurement of heights.

Each stratnm of air has to bear a greater pressure than the stratum next above it, and as its pressing force on other bodies is dependent on the force with which itself is pressed, the barometric column encounters a decreasing pressure in proportion as we ascend from the earth's surface; the manner in which this circumstance is rendered available for the measurement of the altitude of elevated positions or objects, we will now briefly detail.

No sooner had Pascal found his anticipations respecting the fall of the mercury on ascending from the earth's surface to be correct, than he at once conceived the idea of applying that principle to the measurement of heights. To do this, it was, first of all, necessary to determine the comparative state and nature of the air at different elevations; and here Pascal committed a capital error: he supposed that the atmosphere was of equal density throughout,—and that as an inch column of the atmosphere supported thirty inches of mercury, he would only have to ascertain the depression in the mercury on ascending a mountain, and then ascertaining the height by comparing the relative weights of mercury and of air, which has been since determined by Biot and Arago to be 1 to 10,466.

This was soon found to be incorrect, and Halley demonstrated that the density of the air decreases in a geometrical ratio, while the elevation increases in an arithmetical ratio; that is, if at a certain height the density were half of that at the earth's surface, at twice the height it would be $\frac{1}{4}$, at thrice $\frac{1}{8}$, and so on; and it having likewise been determined about that period, that the pressure of aërial fluids is exactly proportional to their density, (a very important and beautiful law,) Halley clearly showed that the ratio of decrease in the pressure was different from that of the increase in the heights.

Now the relation between an arithmetical and a geometrical progression is exactly that which subsists between a series of natural numbers and their logarithms, and Halley conceived the happy idea of applying a common table of logarithms to the solution of these questions: but, it was necessary to determine a unit of his two series, and this he did by computing that the height at which the atmospheric pressure is exactly half that at the earth's surface, must be about $3\frac{1}{2}$ miles; and mathematical considerations, into which we cannot here enter, induced him to fix upon the number 62,170 as a constant multiplier, as follows: observe the height of the mercury at the earth's surface, and then at the elevated station,—take the logarithms of those numbers, and subtract the smaller from the greater,—multiply the difference by 62,170, and the result is the height in English feet: this process has been found to give an exceedingly near approximation, especially in a temperate climate.

The latter half of the last century, however, was enriched by many valuable discoveries concerning the expansion of bodies by heat, and it was soon found that a correction for temperature was necessary in barometrical measurements; a splendid train of investigation occupied the attention of Bouguer, Bernouilli, De Luc, and Laplace, and the result was a formula which grappled with most of the difficulties of the question: to give some idea of the accuracy which De Luc brought into experiments on this subject, it will be sufficient to state, that *two* barometers, and *four* thermometers, were used in each experiment, the exact differences between the indications of all were rigorously noted, and then a series of computations was applied to each observation.

All these computations have been tabularly arranged by Oltmanns, in a convenient way for practice; but Professor Quetelet has given an easy mode, taken from De Luc, of attaining a very near approach to correctness; this mode, which is calculated for French toises, when adapted to English feet, appears in the following form. Multiply the difference of the logarithms of the two heights of the mercury by 63,946; the result is the elevation in English feet: then correct for temperature thus: take the mean of the temperature at the two elevations; if that be 69°·68 Fahrenheit, no correction is necessary; if above that, add $\frac{1}{215}$th to the whole height found, for each degree above 69°·68; if below, subtract the same quantity. For example:—Humboldt found that at the level of the sea, near the foot of Chimborazo, the barometer stood at exactly 30 inches; while at the summit of the mountain, it was only 14·85:—then the logarithm of 30·0 is 1·4771213, and the logarithm of 14·85 is 1·1717237: then subtracting

$$\begin{array}{r} 1{\cdot}4771213 \\ 1{\cdot}1717237 \\ \hline 0{\cdot}3053976 \end{array}$$

Multiply this by 63,546, which produces 19,529 for the number of feet of elevation; if then the mean temperature of the two stations were 69°·68, we should have no correction to make for temperature. This is a near approximation, as the most careful calculation has given 19,332 as the real height, which was probably estimated for a lower temperature.

On comparing this mode with Halley's, it will be seen that the constant factor is larger in the one case than the other, the one being 63,946, and the other 62,170; but we should probably find, that in nearly all cases, the mean temperature between the two elevations would be *less* than 69°·68 Fahrenheit, and a deduction would follow accordingly, on using De Luc's method: thus, if the mean temperature at Chimborazo had been 59°·68, $\frac{10}{215}$ would have to be subtracted, which would reduce the elevation to 18,621 feet, while by Halley's formula it would be 18,987 feet: it seems probable, therefore, that De Luc's method approaches more nearly to perfection, on account of its embracing fluctuation of temperature among its elements.

After the discovery of any principle in science, perhaps the most valuable step in its progress is the first attempt to bring it within the range of popular application: it is then, when the field is tended and cultivated by a multiplicity of labourers, that the seed most rapidly germinates, and produces its wonted fruit. Actuated by the knowledge of this truth, Professor Leslie devised a mode of measuring heights, without the aid of logarithms, and thus placed the computation within the reach of all who knew the merest rudiments of arithmetic; his mode is this: ascertain the exact barometric pressure at the base, and at the summit of the elevation, and then institute the following proposition: as the sum of the two pressures is to their difference, so is the constant number, 52,000 feet, to the answer required (in feet); for example, suppose the two pressures were 29·48 and 26·36—then

As $29{\cdot}48 + 26{\cdot}36 : 29{\cdot}48 - 26{\cdot}36 :: \overset{\text{feet.}}{52{,}000} : \overset{\text{feet.}}{2905{\cdot}4}$, the answer required.

This mode has been found very applicable to the mean temperature of our climate, and for all heights under 5000 feet; it will, therefore, be available for all the elevations in Britain; and we would suggest this to such of our readers as possess facilities for visiting the hilly districts of Scotland, Cumberland, or Wales, as a very delightful source of scientific inquiry; the barometer should have a vernier for reading off hundredths of an inch, as a difference of $\frac{1}{100}$th of an inch, will indicate from 88 to 100 or 110 feet, according to the density or pressure.

It must be understood that *perfect* accuracy can never be depended on in these results, but a sufficiently near approximation, for most purposes, can be obtained.

Soon after Fahrenheit invented the thermometer which bears his name, it occurred to him that, as the temperature which water attains before it boils is dependent on the pressure of the air above it, the boiling-point of water might be available for the measurement of heights, as the density decreases upwards; this principle was afterwards advantageously determined by Saussure, and has been subsequently simplified by the discovery that the boiling-point of water decreases in a geometrical ratio, nearly equivalent to the decrease of atmospheric density, and the following rule has been laid down, adapted to the centigrade thermometer (in which the freezing and boiling-points of water are separated by 100 degrees). For every decrease of 1° Cent. in the boiling-point of water, reckoning 1000 feet of elevation, if the temperature be at or about $5\frac{1}{2}$° Cent. (or 42° Fahr.), but a slight correction is necessary for other temperatures, on account of the change in the density of the air; this correction is computed from the law that the air expands $\frac{1}{480}$th for every degree of Fahrenheit, or $\frac{1}{267}$ for every centigrade degree, and its pressure becomes necessarily lessened. (Centigrade degrees can be easily converted into Fahrenheits, by remembering that one centigrade degree is equal to 1·8° of Fahrenheit; or 1° of Fahrenheit equal to 0·555 of centigrade degrees.)

The limits of our subject will not permit us to enter fully into the phenomena connected with the boiling-points of water; but it would be found that very remarkable results are dependent on the determination of that point; thus, the nutritious principle in many kinds of common animal and vegetable food cannot be extracted at a lower temperature than 212°, and thus those who live in very elevated regions, such as the plains of Mexico, &c., are deprived of many luxuries which their more fortunate, because less elevated, neighbours, are capable of procuring.

This is particularly remarkable at the Hospice de St. Bernard, which is situated in one of the passes of the Alps, at an elevation of 8600 feet; there are many kinds of animal and vegetable food, which the monks cannot prepare by boiling, as water boils at 203° at that elevation, which is an insufficient heat for the purpose: and thus that isolated little band, situated at the boundary of the beautiful Swiss valleys on the north, and the rich plains of Savoy on the south, seem as it were cut off from participating in many comforts, from the simple fact that they cannot make their boiling water as hot as that of their neighbours.

It has been suggested by Dr. Arnott, that probably the peculiar flavour which London porter possesses, when compared with other malt liquors, may be owing to the great depth of the vats in which the ingredients are prepared; it is probable that the water at the bottom or lower part of those vats is at a higher temperature than 212° when boiling, on account of the immense pressure of the superincumbent water, and that this higher temperature extracts properties from the vegetable ingredients for which water at 212° would not avail.

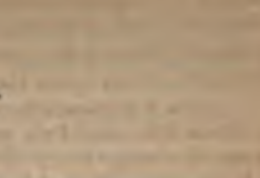
In concluding this article, we will briefly mention a phenomenon called barometric light, which appears to be wholly of electric origin. If the mercury in a barometric tube be shaken, luminous indications may be observed, which in a darkened room are very striking: the friction between the mercury and the glass, uninfluenced by the presence of air, elicits electricity from the glass. A similar effect can be produced by placing a cup of mercury under the receiver of an air-pump; as the exhaustion proceeds, the mere shaking produced by the handle of the pump, by causing friction between the mercury and the cup elicits a luminosity so decided, that the whole apparatus becomes visible in a darkened room.

We have thus thrown together, in a popular form, the principal elements necessary for a right appreciation of the principles of that beautiful instrument the barometer:—beautiful, whether viewed in connexion with the atmospheric phenomena on which its action depends, or with reference to the impulse which its discovery gave to that burst of mind, which in the sixteenth century displayed itself in almost every country in Europe; when men began rightly to perceive that the exquisite Laws of Nature are not to be appreciated by closet reasoning, unless conducted hand in hand with experimental inquiry.

MISCELLANEA.

Experimental Proof that Atmospheric Air is necessary to the developement of Living Organisms.

"The access of air has been regarded as a necessary condition for the primary formation of *infusoria* from decomposing organic matter, so that the mere circumstance of covering an infusion with a stratum of oil, removed that condition. But the question still remained undecided, Does the access of atmospheric air, light, and heat to such substances, include of itself all the conditions for the primary formation of animal or of vegetable organisms? And in this point of view new direct experiments were considered to be very desirable. The difficulty to be overcome consisted in the necessity of being assured, first, that at the beginning of the experiment there was no animal or germ capable of developement in the infusion; and secondly, that the air admitted contained nothing of the kind. For this purpose I constructed the apparatus represented in the annexed figure.



"I filled a glass flask half full of distilled water, in which I mixed various animal and vegetable substances; I then closed it with a good cork, through which I passed two glass tubes bent at right angles, the whole being air-tight. It was next placed in a sand-bath, and heated until the water boiled violently, and thus all parts had reached a temperature of 212° F. While the watery vapour was escaping by the glass tubes, I fastened at each end an apparatus which chemists employ for collecting carbonic acid; that to the left was filled with concentrated sulphuric acid, and the other with a solution of potash. By means of the boiling heat every thing living, and all germs, in the flask or in the tubes, were destroyed, and all access was cut off by the sulphuric acid on the one side, and the potash on the other. I placed this easily moved apparatus before my window, where it was exposed to the action of light, and also, as I performed my experiments during the summer, to that of heat. At the same time I placed near it an open vessel, with the same substances that had been introduced into the flask, and also after having subjected them to a boiling temperature. In order now to renew constantly the air within the flask, I sucked with my mouth, several times a day, the open end of the apparatus filled with solution of potash; by which process the air entered my mouth from the flask through the caustic liquid, and the atmospheric air from without entered the flask through the sulphuric acid. The air was of course not at all altered in its composition by passing through the sulphuric acid in the flask, but if sufficient time was allowed for the passage, all the portions of living matter, or of matter capable of becoming animated, were taken up by the sulphuric acid and destroyed. From the 28th May till the beginning of August, I continued uninterruptedly the renewal of the air in the flask, without being able, by the aid of the microscope, to perceive any living animal or vegetable substance, although during the whole of the time I made my observations almost daily on the edge of the liquid; and when at last I separated the different parts of the apparatus, I could not find in the whole liquid the slightest trace of *infusoria*, of *confervæ*, or of mould. But all three presented themselves in great abundance a few days after I had left the flask standing open. The vessel which I placed near the apparatus contained on the following day vibriones and monades, to which were soon added larger polygrastric *infusoria*, and afterwards *rotatoriæ*."—Schulze.

St. Elmo's Fire in Orkney.

"During last February, 1837, (Sunday, 19,) in a tremendous gale, my large boat sunk, and it was late on Tuesday night before we could get her up and drawn to the shore, after which we had to wait till three o'clock next morning till the tide ebbed from her; she was during this time attached to the shore by an iron chain, about thirty fathoms long, which did not touch the water, when to my astonishment I beheld a sheet of blood-red flame, extending along the shore for about thirty fathoms broad and 100 fathoms long, commencing at the chain and stretching along the shore and sea in the direction of the shore, which was E.S.E., the wind being N.N.W. at the time. The flame remained about ten seconds, and occurred four times in about two minutes. Whilst I was wondering not a little, the boatmen, who, to the number of twenty-five or thirty, were sheltering themselves from the weather, came running down apparently alarmed, and asked me if I had ever seen anything like this before. I was about reply, when I observed their eyes directed upwards, and found they were attracted by a most splendid appearance at the boat. The whole mast was illuminated, and from the iron spike at the summit, a flame of one foot long was pointed to the N.N.W., from which a thunder-cloud was rapidly coming. The cloud approached, which was accompanied by thunder and hail; the flame increased and followed the course of the cloud till it was immediately above, when it arrived at the length of nearly three feet, after which it rapidly diminished, still pointing to the cloud, as it was borne rapidly on to S.S.E. The whole lasted about four minutes, and had a most splendid appearance. I regretted afterwards that I was so occupied with the flame at the mast-head, that I did not observe whether the red flame on the ground continued during the time the cloud was passing."—*Extract of a Letter from William Traill, Esq., Kirkwall, to Professor Traill, dated May* 16, 1837. *Jameson's Journ.*

Contrast in the Vegetation of the two Hemispheres.

"It is a striking and inexplicable phenomenon in the vegetation of the southern hemisphere of our planet, that there the vegetation exhibits remarkable differences, not only according to a change of latitude, but also according to a change of longitude, without at all taking into consideration the great difference of character in the vegetation of the southern hemisphere from that of the north; and that, in so far at least as the higher latitudes are concerned, there are in reality in the northern hemisphere only *representatives* of the vegetable forms of the corresponding zones of the southern hemisphere. And the same is the case *vice versâ;* for there occur also in the higher latitudes of the southern hemisphere representatives of the corresponding latitudes of the northern hemisphere. And, in the same manner as we find the vegetation of the plains of the southern hemisphere, so is it also on the highest mountains; and also in those districts of Upper Peru from which we started. The vegetation of the heights of Upper Peru has hardly any resemblance to that of the Himalayah: there we hardly find representatives of those genera which in the Himalayah, and generally in the mountains of the northern hemisphere, form the alpine vegetation. On the contrary, there occur distinct forms of genera and families, which are partly quite foreign to our northern hemisphere, and partly belong only to its more southern portions, and never present themselves in the highest latitudes, or ascend to the highest regions of our mountains. To the exquisite primroses of the alpine flora of our northern hemisphere there correspond the singularly modelled form of the Merlineæ and that of the Verbenaceæ. The genera *Mimulus, Alstrœmeria, Calceolaria, Tropæolum, Calandrinia,* and *Adesmia,* which now form the greatest ornaments of our gardens, are sometimes collected into the most enlivening patches close to the limits of perpetual snow; and the genera *Espeletia, Oxalis, Acæna, Nierembergia, Atropa, Lycium, Culcitium, Chuquiraga, Sida,* and many others, contribute to clothe the region of alpine plants; while of all these genera not a trace is found in the region of alpine plants in the northern hemisphere. The genus *Sida,* and the Malvaceæ generally, remain at a distance from the Arctic zone in our hemisphere, and do not descend to the region of the alpine plants; while on the Peruvian Cordillera they extend to the limits of perpetual snow, and there actually constitute the most remarkable forms."—MEYEN. *Wiegmann's Archiv. für Naturgeschichte.*

Prize Subjects, 1837. *Institution of Civil Engineers*, (*Second Comm.*)

1. THE Nature and Properties of Steam, considered with reference to its application as a moving power for Machinery.

2. The warming and ventilating Public Buildings and Apartments, with an account of the Methods which have been employed most successfully for ensuring a healthy state of the atmosphere.

3. An Account and Drawings of the original construction and present state of the Plymouth Breakwater.

4. The ratio, from actual experiment, of the Velocity, Load, and Power of Locomotive Engines on Railways. 1st. Upon Levels; 2nd. Upon Inclined Planes.

5. Drawings, Description, and Account of the Principles of Huddart's Rope Machinery at Limehouse[*].

6. The Sewerage of Westminster.

7. Drawings and Description of the Shield at the Thames Tunnel, with an accurate Account of the Method by which it is advanced and worked.[*]

In the distribution of the Premiums, no distinction will be made betwixt the communications of Members, Associates, and others in no way connected with the Institution, whether Natives or Foreigners.

The Council will not consider themselves bound to award any Premiums should the communication not be of adequate merit, but the Council will award valuable Premiums to communications of distinguished merit, or more than one Premium, should there be several communications on the same subject deserving this mark of distinction.

The communications must be forwarded to the House of the Institution, 1, Cannon Row, Westminster, on or before the 31st of March, 1838.

In pointing out the above subjects, the Council wish it to be understood, that it is not intended to confine the Premiums of the Institution to Memoirs and Drawings on the above Subjects, but that all communications of value will be rewarded. The Council publish these in the hope of directing attention to subjects of great general interest, and with the view of pointing out the kind of communications which they are anxious to reward. The Council trust that those who have possession of the Drawings and details of works of a kind similar to those just mentioned, will feel the importance of leaving to posterity, some public record of the execution and present state of the works, and afford those who are disposed to prepare these records every facility of access to such documents.

Expression for the Dip, &c., of Stratified Rocks.

"LET A and B be two stations, whose difference of level is denoted by h, positive when B is above A, and negative when otherwise; and let d represent the horizontal distance between them. Also let D denote the angle of the dip of the stratum observed at A; I the horizontal angle formed by the plane of the dip and a vertical plane passing through A and B; and lastly, let E denote the angle of elevation of B with respect to A, when that angle can be measured by the two stations being visible from each other. Then if H denote the vertical line from B to the plane of the stratum passing through A, we have

$$\mathrm{H} = h + d\,(\tan.\ \mathrm{D} \cos.\ \mathrm{I});$$

$$\text{or, } \mathrm{H} = d\,(\cot.\ \mathrm{E} + \tan.\ \mathrm{D} \cos.\ \mathrm{I}). \quad . \quad . \quad (1)$$

"If t denote the perpendicular thickness of a bed of the same stratified rock, so that the parallel planes passing through A and B are on the opposite sides of the seam, or stratum; then

$$t = \mathrm{H} \cos.\ \mathrm{D} = d\,(\cos.\ \mathrm{D} \cot.\ \mathrm{E} + \tan.\ \mathrm{D} \cos.\ \mathrm{I});$$

$$\text{or, } t = d\,(\cos.\ \mathrm{D} \cot.\ \mathrm{E} + \sin.\ \mathrm{D} \cos.\ \mathrm{I}). \quad . \quad . \quad . \quad . \quad (2)$$

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[*] Said to be bought by the Russian government.

"When $t = o$, that is, when A and B are in the same plane of a face of the stratum, the formula (2) may be expressed entirely in circular functions, and becomes

$$-\cot.\ \mathrm{E}\cos.\ \mathrm{K} = \sin.\ \mathrm{D}\cos.\ \mathrm{I}$$

$$\text{or, } -\cot.\ \mathrm{E} = \tan.\ \mathrm{D}\cos.\ \mathrm{I} \quad . \quad . \quad . \quad . \quad (3)$$

"This expression may be applied to determine whether two points, in a disjoined stratified rock, of the same character, belong to the same layer of the bed, when these points are separated by an extensive ravine or valley. The expression (1) may be of considerable use to miners and practical engineers."—ANDERSON. *Jameson's Journ.*

Electro-magnetic Motors.

PROF. SILLIMAN having been invited to examine, and report upon, an Electro-magnetic Machine, invented by Mr. Thomas Davenport, of Brandon, near Rutland, Vermont, gave the subject his attention in March last, and inserted the following description in the number of his Journal which was published in April.

The Machine was exhibited by means of a working-model, in two varieties of form, viz.—

1. *The Rotary Machine, composed of revolving Electro-magnets, with fixed permanent Magnets.*

The moving part is composed of two iron bars placed horizontally, and crossing each other at right angles. They are both five and a half inches long, and they are terminated at each end by a segment of a circle made of soft iron; these segments are each three inches long in the chord line, and their position, as they are suspended upon the ends of the iron bars, is horizontal.

This iron cross is sustained by a vertical axis, standing with its pivot in a socket, and admitting of easy rotation. The iron cross bars are wound with copper wire, covered by cotton, and they are made to form, at pleasure, a proper connexion with a small circular battery, made of concentric cylinders of copper and zinc, which can be immersed in a quart of acidulated water. Two semicircles of strongly magnetized steel form an entire circle, interrupted only at the two opposite poles, and within this circle, which lies horizontally, the galvanized iron cross moves in such a manner that its iron segments revolve parallel and very near to the magnetic circle, and in the same plane. Its axis at its upper end, is fitted by a horizontal cog-wheel to another and larger vertical wheel, to whose horizontal axis weight is attached, and raised by the winding of a rope. As soon as the small battery, destined to generate the power, is properly connected with the machine, and duly excited by diluted acid, the motion begins, by the horizontal movement of the iron cross, with its circular segments or flanges. By the galvanic connexion these crosses and their connected segments are magnetized, acquiring north and south polarity at their opposite ends, and being thus subjected to the attracting and repelling force of the circular fixed magnets, a rapid horizontal movement is produced, at the rate of two to three hundred revolutions in a minute, when the small battery was used, and over six hundred with a calorimotor of large size. The rope was wound up with a weight of fourteen pounds attached, and twenty-eight pounds were lifted from the floor. The movement is instantly stopped by breaking the connexion with the battery, and then reversed by simply interchanging the connexion of the wires of the battery with those of the machine, when it becomes equally rapid in the opposite direction.

The machine, as a philosophical instrument, operates with beautiful and surprising effect, and no reason can be discovered why the motion may not be indefinitely continued. It is easy to cause a very gradual flow of the impaired or exhausted acid liquor from, and of fresh acidulated water into, the receptacle of the battery, and whenever the metal of the latter is too much corroded to be any longer efficient, another battery may be instantly substituted, and that even before the connexion of the old battery is broken. As to the energy of the power, it becomes at once a most interesting inquiry, whether it admits of indefinite increase? To this inquiry it may be replied, that provided the magnetism of both the revolving cross and of the fixed circle can be indefinitely increased, then no reason appears why the energy of the power cannot also be indefinitely increased. Now, as magnets of the common kind, usually called permanent magnets, find their limits within, at most, the power of lifting a few hundred pounds, it is obvious that the revolving galvanic magnet must, in its efficiency, be limited, by its relation to the fixed magnet. But it is an important fact, discovered by experience, that the latter is soon impaired in its power by the influence of the revolving galvanic magnet, which is easily made to surpass it in energy, and thus, as it were, to overpower it. It is obvious, therefore, that the fixed magnet, as well as the revolving, ought to be magnetized by galvanism, and then there is every reason to believe that the relative equality of the two, and of course their relative energy, may be permanently supported, and even carried to an extent much greater than has been hitherto attained.

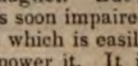
2. *Rotating Machine, composed entirely of Electro-magnets, both in its fixed and revolving members.*

It is the same machine that has been already described, except that the exterior fixed circle is now composed entirely of electro-magnets.

The entire apparatus is therefore constructed of soft unmagnetic iron, which, being properly wound with insulate copper-wire, is magnetized in an instant, by the power of a very small battery.

The machine is indeed the identical one used before, except that the exterior circle of permanent magnets is removed, and in its place is arranged a circle of soft iron, divided into two portions to form the poles.

These semicircles are made of hoop-iron, one inch in width, and one-eighth of an inch in thickness. They are wound with copper-wire insulated by cotton—covering about ten inches in length on each semicircle, and returning upon itself by a double winding, so as to form two layers of wire, making on both semicircles about one thousand and five hundred inches.



The iron was not wound over the entire length of one of the steel semicircles; but both ends were left projecting, and being turned inward, were made to conform to the bend of the other part, as in the annexed figure, which is intended to represent one of them; each end that is turned inward, and not wound, is about one-third of the length of the semicircle. These semicircles being thus fitted up, so as to become, at pleasure, galvanic magnetics, were placed in the same machine that has been already described, and occupied the same place that the permanent steel magnets did before. The conducting wires were so arranged, that the same current that charged the magnets of the motive wheel, charged the stationary ones placed around it, only one battery being used. It should be observed, that the stationary galvanic magnets thus substituted for the permanent steel ones, were only about half the weight of the steel magnets. This modification of the galvanic magnet, is not of course the best form for efficiency; this was used merely to try the principle, and this construction may be superseded by a different and more efficient one. But with this arrangement, and notwithstanding the imperfection of the mechanism of the machine—when the battery, requiring about one quart of diluted acid to immerse it, was attached, it lifted 16 lbs. very rapidly, and when the weight was removed, it performed more than 600 revolutions per minute.

So sensible was the machine to the magnetic power, that the immersion of the battery one inch into the acidulated water was sufficient to give it rapid motion, which attained its maximum, when the battery was entirely immersed. It appeared to me that the machine had more energy with the electro-magnets, than with those that were permanent, for with the smallest battery, whose diameter was three inches and a half—its height five inches and a half, and the number of concentric cylinders three of copper and three of zinc, the instrument manifested as great power as it had done with the largest batteries, and even with a large calorimotor, when it was used with a permanent instead of a galvanic magnet. With the small battery and with none but electro or galvanic magnets, it revolved with so much energy as to produce a brisk breeze, and powerfully to shake a large table on which the apparatus stood.

Although the magnetization of both the stationary and revolving magnets was imparted by one and the same battery, the magnetic power was not immediately destroyed by breaking the connexion between the battery and the stationary magnet; for, when this was done, the machine still performed its revolutions with great, although diminished energy; in practice this might be important, as it would give time to make changes in the apparatus, without stopping the movement of the machine.

Conclusions.—1. It appears, then, from the facts stated above, that electro-magnetism is quite adequate to the generation of rotary motion.

2. That it is not necessary to employ permanent magnets in any part of the construction, and that electro-magnets are far preferable, not only for the moving but for the stationary parts of the machine.

3. That the power generated by electro-magnetism may be indefinitely prolonged, since, for exhausted acids and corroded metals, fresh acids and batteries, kept always in readiness, may be substituted, even without stopping the movement.

4. That the power may be increased beyond any limit hitherto attained, and probably beyond any which can be *with certainty* assigned; since, by increasing all the members of the apparatus,—due reference being had to the relative proportionate weight, size, and form of the fixed and moveable parts, to the length of the insulated wires, and the manner of winding them, and to the proper size and construction of the battery, as well as to the nature and strength of the acid or other exciting agent, and the manner of connecting the battery with the machine,—it would appear certain, that the power must be increased in some ratio which experience must ascertain.

5. As electro-magnetism has been experimentally proved to be sufficient to raise and sustain several thousands of pounds, no reason can be discovered why, when the acting surfaces are, by skilful mechanism, brought as near as possible, without contact, the continued exertion of the power should not generate a continued rotary movement, of a degree of energy inferior indeed to that exerted in actual contact, but still nearly approximating to it.

6. As the power can be generated cheaply and certainly,—as it can be continued indefinitely,—as it has been very greatly increased by very simple means,—as we have no knowledge of its limit, and may therefore presume on an indefinite augmentation of its energy, it is much to be desired, that the investigation should be prosecuted with zeal, *aided by correct scientific knowledge*, by *mechanical skill*, and by *ample funds*. It may, therefore, be reasonably hoped, that science and art, the handmaids of discovery, will both receive from this interesting research, a liberal reward.

Science has thus, most unexpectedly, placed in our hands a new power of great but unknown energy.

It does not evoke the winds from their caverns; nor give wings to water by the urgency of heat; nor drive to exhaustion the muscular power of animals; nor operate by complicated mechanism; nor accumulate hydraulic force by damming the vexed torrents; nor summon any other form of gravitating force; but, by the simplest means—the mere contact of metallic surfaces of small extent, with feeble chemical agents, a power everywhere diffused through nature, but generally concealed from our senses, is mysteriously evolved, and by circulation in insulated wires, it is still more mysteriously augmented, a thousand and a thousand fold, until it breaks forth with incredible energy; there is no appreciable interval between its first evolution and its full maturity, and the infant starts up a giant.

Nothing since the discovery of gravitation and of the structure of the celestial systems, is so wonderful as the power evolved by galvanism; whether we contemplate it in the muscular convulsions of animals, the chemical decompositions, the solar brightness of the galvanic light, the dissipating consuming heat, and, more than all, in the magnetic energy, which leaves far behind all previous artificial accumulations of this power, and reveals, as there is full reason to believe, the grand secret of terrestrial magnetism itself.

B. S.

Present uncertainty as to the Mean Level of the Ocean.

'NATURAL philosophers are at present not quite agreed upon the mode of determining the mean level of the ocean. Whether it is to be deduced from the averages between the highest and lowest spring-tide, or from the averages of all the intermediate ones, or from the means of the instantaneous heights of the tide at all intervening periods, or by whatever other process, its true level is yet to be ascertained. It may, perhaps, be useful to suggest that, besides the actual level of the sea at any particular place, it would be also desirable to ascertain whether the time of high water at given epochs is not itself a changeable quantity. These reflections, however, are only thrown out with the view of exciting discussion on a subject involved at present in great mathematical difficulties, and possessing, at the same time, the highest practical importance."—BABBAGE. *Jameson's Journ.*

Bearing upon the Hull Steam-boat Explosion Question.

"DR. JOHN DAVY, fully avowing the fitness of zinc to protect iron from corrosion in sea-water, has remarked, that, by using this mode of preservation for iron steam-boilers, it is to be questioned whether danger may not arise from the inflammable gas mixing with the steam. But besides the very small quantity of that gas, which can never increase indefinitely in the boiler, on account of its escaping from time to time together with the steam, I think that hydrogen gas, even in a great quantity, included in a steam-boiler, will not be more dangerous there than the same quantity in every closed gasometer, and can, when mixed with steam, by no means cause an explosion. When the bottom or the sides of a steam-boiler are incandescent for want of water, the boiler may undoubtedly burst, as dreadful experience has often taught: but in this case it is only the suddenly increased tension of the steam that makes the danger imminent, even without the presence of any inflammable or explosive gas.

"On the contrary, I perfectly agree with Dr. Davy in his statement, that the protection of iron-boilers of steam-vessels is not a matter of absolute necessity, since experience has taught us that the oxidation of the iron cannot take place after the sea-water boils, a circumstance which generally occurs. According to his experiments, which we found perfectly confirmed, the iron in sea-water is not oxidated by decomposition of sea-water, but chiefly by the air contained in it, and when this is expelled by means of an air-pump, or by boiling, the oxidation of the iron immediately ceases."—A. VAN BEEK. *Jameson's Journ.*

Mean Variation of the Magnetic Needle in England.

THE amount of the variation has been observed in England, slowly to oscillate through an arc of 36°, it being now nearly 25½° to the westward of the true north at Falmouth; whereas, about 250 years ago, it was noticed in London to be 11° to the eastward of north, which gives a mean magnetic declination of 18° to the westward of the true meridian. The recent observations of Captain Mudge in Donegal Bay (see p. 74) would extend this arc to more than 38°, and consequently the mean declination to 19° at least.

Mr. R. W. Fox stated to a visiter, at the Anniversary of the Polytechnic Society of Cornwall in September last, that his observations gave 25° 25′ west. If this be compared with the variation at London *, it will be found that the variation at Falmouth is 1° 47′ 30″, more westerly than at London, while it is less westerly than the variation lately observed in Donegal Bay, Ireland, by 1° 55′.

On the Burning of Limestone.

M. GAY-LUSSAC observes, that it has long been supposed that the calcination of limestone is accelerated by the presence of water; and the opinion appears to be adopted by lime-burners in general. M. Dumas admits the influence of water to be unquestionable, and he gives two explanations of its action; "either," says he, "it acts upon the carbonate, and forms a temporary hydrate, taking the place of the carbonic acid for a very short time, for the hydrate of lime itself is decomposed by a red heat; or the water, being decomposed by the carbon employed as a combustible, is converted into various gases, of which carburetted hydrogen forms a part, and this reacting upon the carbonic acid of the carbonate, tends to convert it into oxide of carbon, and thus facilitates the separation from the carbonate of lime. Thus, limestone fresh quarried, and consequently still moist, ought to be more readily calcined than the stone which is nearly dry; and most lime-burners are well acquainted with this fact, and sprinkle with water the limestone which has been long procured, before they charge the kilns with it."—(Dumas, *Traité de Chimie*, ii. p. 482.) The first of these explanations is, however, inadmissible, for hydrate of lime is decomposed at a temperature lower than that at which carbonate of lime is decomposed under the influence of water. On considering the circumstances of the combustion in limekilns, the second explanation does not appear to M. Gay-Lussac to be applicable, and he therefore proceeds to some observations which he thinks will explain the influence of the water. A porcelain tube was filled with bits of marble and placed in a furnace, the heat of which was easily regulated; a glass retort containing water was adapted to one end of the tube, and at the other a glass tube to receive the carbonic acid gas. The heat was raised sufficiently high to decompose the marble, and on shutting the ashpit door the heat fell to a dull red, and the carbonic acid ceased to come over; and at this instant the water was boiled in the retort, and carbonic acid was abundantly obtained. On discontinuing the vapour, the disengagement of acid instantly ceased, and returned only on continuing the vapour. It appears, therefore, proved that the vapour of water actually favours the decomposition of the carbonate of lime by heat, and that by its operation this decomposition may occur at a lower temperature than is otherwise requisite. M. Gay-Lussac considers the action of the water to be entirely mechanical. When the carbonate of lime is exposed to heat, and is near the point of decomposition, an atmosphere of carbonic acid is formed around it, which presses upon the acid remaining combined, so that the latter, that it may be disengaged, must overcome the pressure of this atmosphere. This, however, cannot occur without still further raising the temperature, or removing the carbonic acid and forming a vacuum, or by displacing it, either by the vapour of water, or some other elastic fluid, such as atmospheric air. This explanation is supported by the following experiment: Carbonate of lime was heated in a porcelain tube nearly to its decomposing point, and then a current of atmospheric air was passed over it. The disengagement of carbonic acid immediately commenced, continued with the current of air, ceased when it was stopped, and recommenced with it. M. Gay-Lussac, therefore, considers it as proved, that the influence of aqueous vapour, in the calcination of limestone, is confined to the production of a vacuum for carbonic acid, and to the prevention of the pressure of the disengaged acid upon that which remains with the lime. When the vapour is present, a lower temperature is required to dislodge the carbonic acid; but the importance of this influence must not be overrated. The water, in calcareous stones, is mechanically interposed between their particles; and, with the exception of some minute portions, which remain confined in the centre of pieces too large to allow of the heat penetrating and vaporizing them, the greater part of the water must evaporate without any useful result, and, on the contrary, with the loss of fuel, before the limestone has acquired the temperature requisite for its decomposition. M. Gay-Lussac thus concludes:—I am certainly convinced that the vapour of water favours the calcination of limestone, but I am doubtful as to its possessing real advantages, because there is not a great difference in the temperature at which it decomposes alone or with the vapour of water; besides, if the vapour of water only exerts a mechanical action similar to that of atmospheric air, any important advantage which it possesses over the aëriform current continually passing over the burning mass, is not evident. The readier decomposition of carbonate of lime by the access of aqueous vapour, or rather by means of a vacuum, cannot be considered as an isolated fact. It may be regarded as an established principle, that when one or several gaseous products are obtained, either by the action of heat or a chemical agent, the decomposition may be generally facilitated by keeping the bodies in vacuo, or by preventing the gaseous fluids from pressing upon it. And on the other hand, the decomposition may be retarded or entirely prevented, by forming round the body a sufficient pressure of an elastic fluid of the same nature as that which is to be disengaged. It is thus in the curious experiment of Sir James Hall; carbonate of lime was fused at a very high temperature, without being decomposed, under the influence of a sufficient pressure of carbonic acid.—*Ann. de Chimie.*

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* Given p. 234, Vol. III.

A Crow-bar,—a Magnetic Needle!

THE following case of natural magnetism has no equal known at present:—

"A bed of magnetic iron ore not only magnetized so powerfully the iron instruments used to break it up as to adhere to them in large tufts of the fragments of the iron ore, but a crow-bar suspended freely over the iron ore takes the position in the magnetic meridian, and thus becomes a true but gigantic needle."—JACKSON. *Report on the Geology of Maine, United States. Silliman's Journal.*

Fall of Fishes from the Atmosphere.

"THE fact that fishes fall from the atmosphere in the rainy season, however incredible it may appear, has been so frequently attested by credible witnesses, that it can scarcely be doubted. As for myself, my credulity is compelled to yield to the discovery I made one day of a small fish in my pluviometer, which was situated on an isolated pile of stones, about five feet high, in my garden at Benares. A note from Mr. Cameron informs me, that a rain of fishes occurred on the 19th of February, 1830, near Feridpoor. This fact was asserted before a magistrate by many ocular witnesses, and it was their concurring testimony, that towards noon of the above-mentioned day, the sky was obscured, the rain commenced to fall, and shortly after fishes of various sizes fell from the atmosphere. A large number were collected by several witnesses; some were found destitute of a head, and had commenced to putrefy; others were entire and fresh, but no one dared to eat them."—PRINSEP. *Edit. Bengal Asiatic Soc. Journ.*

Ripple-Marks. Mackerel-Sky. Mottled Solar Surface.

"THE small waves raised on the surface of the water, by the passage of a slight breeze, are called ripple; and a series of marks, very similar in appearance, which are sometimes seen at low water, on the flat part of a sea-beach formed of fine sand, are called ripple-marks. Such marks occur in various strata; and are regarded as evidence of their having been formed beneath the sea. Similar appearances occur when a strong wind drives over the face of a sandy plain.

"It appears that two fluids of different specific gravity, the lighter passing over the surface of the former, always concur in the formation of ripple. It seems also, that the lines of ripple-mark are at right angles to the direction of the current which forms them.

"If a fluid like air pass over the surface of perfectly quiescent water, in a plane absolutely parallel, it will have no effect; but if it impinge on the surface of that water with the slightest inclination, it will raise a small wave, which will be propagated by undulations to great distances. If the direction of the wind is very nearly parallel to the surface of the water, this first wave, being raised above the general surface, will protect that part of the water immediately beyond it from the full effect of the wind, which will therefore again impinge upon the water at a little distance; and, this concurring with the undulation, will tend to produce another small wave, and thus again, new waves will be produced. But the under surface of the air itself will also assume the form of waves; and so, on the slightest deviation at any one point from absolute parallelism in the two fluids, their whole surfaces will become covered with ripples.

"If one of the fluids be water, and the lower fluid be fine sand, partially supported in water, these marks do not disappear when the cause ceases to act; as they do when formed by air on the surface of water. These are the marks we observe when the tide has receded from a flat sandy shore.

"If, after the formation of ripple-marks at the bottom of a shallow sea, some adjacent river, or some current, deposit upon them the mud which it holds in suspension, then the former marks will be preserved, and new ripple-marks may appear above them. Such is the origin of those marks we observe in various sand-stones, from the most recent down to those of the coal-measures.

"Dr. Fitton informs me, that he found the sand-hills on the south of Etaples (in France), consisting of ripple-marks on a large scale. They are crescent-shaped hillocks, many of which are more than a hundred feet high. The height is greatest in the middle of the crescents, declining towards the points; and the slope on the inner side of the crescent, which is remote from the prevailing direction of the winds, is much more rapid than that on which it strikes.

"Mr. Lyell has observed and described this mode of formation of ripple on the dunes of sand near Calais; remarking, that in that case there is an actual lateral transfer—the grains of sand being carried by the wind up the less inclined slope of the ripple, and falling over the steep scarp. I have observed the same fact at Swansea.

"A similar explanation seems to present itself as the origin of that form of clouds familiarly known as 'a mackerel sky'—a wave-like appearance, which probably arises from the passage of a current of air above or below a thin stratum of clouds. The air being of nearly the same specific gravity as that of the cloud it acts upon, would produce ripples of larger size than would otherwise occur.

"The surface of the sun presents to very good telescopes a certain mottled appearance, which is not exactly ripple, and which it is difficult to convey by description. It may, however, be suggested, that wherever such appearances occur, whether in planetary or in stellar bodies, or in the minuter precincts of the dye-house and the engine-boiler, they indicate the fitness of an inquiry, whether there are not two currents of fluid or semi-fluid matter, one moving with a different velocity over the other, the direction of the motion being at right angles to the lines of waves."—Babbage. *Jameson's Journ.*

Magnetic Variation in Donegal Bay, Ireland.

From observations made by Captain Mudge during the last year in Donegal Bay, on the north-west of Ireland, the variation of the magnetic needle, in that part, was then 27° 20′ West. This is 3° 42′ 30″ more to the westward than at London, and 1° 55′ more than at Falmouth.

Vegetable Origin of Amber.

"While, during the month of April, 1836, I was engaged in the examination of the deposit of brown coal at Müskau, I discovered, besides a rhizomorpha and a lichen allied to the Pyrenula nitida (the only representatives of this family at present known in the flora of the ancient world), a large quantity of amber, which occurs in fossil wood apparently coniferous, partly in large disseminated portions, and partly in the resin vessels themselves. A fir cone, found there by Mr. Kehlosen, director of the alum manufactory, approaches most nearly the cone of the Pinus sylvestris, but differs exceedingly from some others which were obtained at Salyhausen, in the Wetterau, and which have been kindly placed at my disposal by Mr. Keferstein. These belong evidently to the genus Abies, and still contain between and on the scales a large quantity of amber, and may therefore with much greater reason be regarded as the cones of the amber-tree, than the cones found included in amber. Specimens of the latter description are extremely rare, but Dr. Behrendt of Dantzic, and Prof. Reich of Berlin, each possess one, and both are very nearly allied to the genus Larix, as was formerly remarked of the last specimen by Professor Link; both belong to the same species, and only differ in size. Besides alluding to these vegetable productions yielding amber, all of which have been found in the brown coal formation, I have to mention an observation which is probably new, and which has been communicated to me by Dr. Schneider of Bunzlaw, viz. that amber occurs in coniferous plants associated with ferns in the coal of Wenig-Rackvity, a deposit that has been referred by Raumer to the quader-sandstone. Since then it appears that we already know four different species of trees which afford amber, (and the number would doubtless be increased by attentive investigation), the probability seems to me to be rendered still stronger, *that amber is nothing else than an indurated resin derived from various trees of the family of the Coniferæ; which resin is found in a like condition in all zones, because its usual original depositories, viz., beds of brown coal, have been formed almost everywhere under similar circumstances.*" —GÖPPERT. *Poggendorff's Annalen.*

English and French Hydrography.—Can either be depended upon?

ONE of the last arrived vessels from the United States has brought to England the twelfth edition of "Blunt's American Coast Pilot," the preface of which is dated 1st June, 1837. This work, of high reputation, and containing a mass of the most valuable information to mariners, collected with scrupulous care and indefatigable attention, has the following very startling passage, p. 715:—

"It may be remarked, that the recent English and French surveys of the coast of South America, differ from five to ten miles in longitude* by their chronometers, in every place where both have observed; we therefore have taken the French observations from St. Luis to the River Plate, as there is a regularly connected chain of observations, and the English, from thence to Cape Horn, for the same reason."

No comment is necessary from us. The extent and singular character of the variation, and the parties implicated, will insure it a early examination. We cannot, however, refrain from asking one question: Supposing the fact to be true, how came the news of this singular discrepancy to have reached Europe first from New York?

Hopes Deferred. Third Series.

A JOURNAL of the "Patents for Inventions' Bill." Session 1837!

14th Feb.

Patents for Inventions.—Bill to alter and amend the Patent Laws, and for better securing to individuals the benefit of their inventions, *ordered* to be brought in by Mr. Mackinnon† and Mr. Baines‡.

15th Feb.

Patents for Inventions' Bill, "to amend the practice relating to Letters-Patent for inventions, and for the better encouragement of arts and manufactures," *presented* and read 1°; to be read 2° on *Wednesday*, 1st of March, and to be *printed.*

1st March, (14 *Days from First Reading.*)

"Patents for Inventions' Bill—Second Reading *deferred* (for *forty-two days*), till *Wednesday*, 12th April."

12th April, (56 *Days from First Reading.*)

"Patents for Inventions' Bill—Second Reading *deferred* (for *thirty-five days*), till *Wednesday*, 17th May."

17th May, (91 *Days from First Reading.*)

No notice of the Bill in the "Votes and Proceedings of the House of Commons" of this day.

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* The English make all their points of observation so much to the eastward of the French.

† Member for Lymington.

‡ Member for Leeds.

1st June, (106 *Days from First Reading.*)

" Patents for Inventions' Bill—Second Reading (*deferred for twenty days*), on *Wednesday*, 21st June."

21st June, (126 *Days from First Reading.*)

" Patents for Inventions' Bill" stands as No. 2. among the "Dropped Orders" of this day.

22nd June (127 *Days from First Reading.*)

" Patents for Inventions' Bill,—Second Reading *To-morrow.*"

To-MORROW !—*Alas, this morrow never dawned!*

N.B. A " Letters Patent Bill" will be found among those which received the Royal Assent on the last day of the Session. This must not be confounded, as it has already been, with the long-hoped-for Bill for the Amelioration of the Patent Law. The title of this Act is—

"An Act for better enabling Her Majesty to confer certain Powers and Immunities on Trading and other Companies."

One of its most important enactments provides that the liability of the Members of Trading Companies may be limited to such extent only *per share*, as shall be declared and limited in and by such Letters Patent.

The rapid course of this Bill through the Legislature throws out, in painful relief, the culpable delay, and neglect, and final failure, of the " Patents for Inventions' Bill." It may be useful, in future years, to know what can be done by men of ability and power; and we therefore, in closing the record of " Hopes Deferred" for this Session, shall add to it a memorandum of the passage of the " Letters Patent Bill."

Mr. Poulett Thompson, having previously given notice of his intention to move for such a Bill, was ordered, with the Attorney-General, to bring in the Bill.

——— in another sitting, it was read a *second* time, and *committed.*
On the 25th June. . . . . . . it was *presented*, and read the *first* time.
1st July . . . . it was *considered in Committee.*
4th —— . . . . it was *reported.*
5th —— . . . . it was read a *third* time, amended, and *passed.*
Between the 5th and 15th it was through the regular stages in the House of Lords, was passed in that House with amendments—
On the 15th . . . . the " Lords' Amendments" were agreed to—
—— 17th . . . . it received the " *Royal Assent.*" (*This was on the* 19*th day from the First Reading.)*

Patent-Law Grievance. No. XVII.

THE inventors of this country, and the introducers of inventions of other countries into this, were obliged to pay down to the attorney-general and other agents, &c., of the Government, during the ten years ending December, 1834, more than £313,000, and during the past year above £42,000 (being at the rate of £420,000 in ten years.) It is to be observed that these enormous extortions are *exclusive* of the drawings, engrossings, and all the other charges of the patent-solicitor.

The penalties inflicted on the inventive genius of Britain during the *present* year, up to the 25th ult., in the shape of government stamps and fees on patents, amount to more than £26,000 !

N.B. This sum has been paid in *ready money* on taking the first steps, and as many of the inventors are poor men, (*Operatives,*) and a great many others of them persons to whom it would be very inconvenient to pay at least £100 down, they have been obliged to go into debt, or mortgage or dispose of their inventions, either wholly or in part, &c.

NEW PATENTS. 1837.

SCOTCH.

N.B. The Date is that on which the Patent was sealed and granted. The Abbreviation *For. Comm.*, signifies that the invention, &c., is "a communication from a foreigner residing abroad."

1. William Sharpe, Glasgow, *Scotl.*, Merchant; for an improvement in the treatment of cotton wool in preparation for manufacturing the same into yarn and thread. Jan. 4.

2. William Cooper, Edinburgh, *Scotl.*, Glass Merchant and Stained-glass manufacturer; for an improved method of executing ornaments, devices, colours, or stains, on glass. Jan. 12.

3. Hamer Stansfeld, Leeds, *York.*, Merchant; for certain improvements in machinery for weaving, one of which improvements is applicable to other purposes. Jan. 13. *For. Comm.*

4. Thomas Vaux, Woodford Bridge, *Essex*, Land Surveyor; for a certain mode of constructing and applying a revolving harrow for agricultural purposes. Jan. 14.

5. Charles Thornton Coathupe, Wraxall, *Som.*, Glass Manufacturer; for certain improvements in the manufacture of certain descriptions of glass. Jan. 18.

6. John Ruthven, Edinburgh; for an improvement in the formation of rails or rods for making railways, and in the methods of fixing or joining them. Jan. 20.

7. George Goodlet, Leith, *Edinb.*, Merchant; for a new and improved mode of distilling spirits from wash and other articles, also applicable to general purposes of rectifying, boiling, and evaporating, or concentrating. Jan. 25.

8. Charles Wheatstone, Conduit-st., *Middx.*, and John Green, of Soho-sq. *Middx.*, Musical Instrument Manufacturers; for a new method of forming musical instruments in which continuous sounds are produced from strings, wires, or springs. Jan. 31.

Total, January...8.

February.

9. Peter Spence, Henry-st., Commercial-road, *Middx.*, Chemist, for certain improvements in the manufacture of Prussian blue, prussiate of potash, and plaster of Paris. Feb. 10.

10. Miles Berry, Chancery-lane, *Middx.*, Patent Agent and Mechanical Draftsman; for an improved apparatus for torrefying, baking, and roasting vegetable substances, which, with certain modifications and additions, is also applicable to the evaporation and concentration of saccharine juices and other liquids. Feb. 15. *For. Comm.*

11. John Gemmell, Glasgow, *Lanark.*, Merchant; for certain improvements in steam or other boats or vessels, which are partly applicable to other purposes. Feb. 16.

12. Moses Poole, Lincoln's-inn, *Middx.*, Gent.; for improvements in anchors, and in friction-rollers to facilitate the lowering and raising such and other anchors, which friction-rollers are applicable to other purposes. Feb. 20. *For. Comm.*

13. James Cook, Birmingham, *Warw.*, Gun Manufacturer; for improvements in gas-burners. Feb. 22.

14. Francois de Fausch, Percy-st., Bedford-sq., *Middx.*, Military Engineer; for improvements in apparatus or machinery for propelling of vessels for raising water, and for various other purposes. Feb. 24.

Total, February...6.

March.

15. John Isaac Hawkins, Chase Cottage, Hampstead-rd., Civil Engineer; for certain improvements in the application of the products of combustion in generating and in aiding of steam for giving motion to steam-engines. March 4. *For. Comm.*

16. William Wright, Salford, *Lanc.*, Machine Maker; for certain improvements in twisting machinery used in the preparation, spinning or twisting of cotton, flax, silk, wool, hemp, and other fibrous substances. March 6.

17. Peter Ascanius Tealdi, Manchester, *Lanc.*, Merchant; for a new extract or vegetable acid, obtained from substances not hitherto used for that purpose, which may be employed in various processes of manufacture, and in culinary or other useful purposes, together with the process of obtaining the same. March 6. *For. Comm.*

18. John Burns Smith, Salford, *Lanc.*, Spinner; and John Smith, Halifax, *York.*, Dyer; for a certain method of tentering, stretching, or keeping out cloth to its width (made either of cotton, silk, wool, or any other fibrous substances) by machinery. March 6.

19. Edmund Shaw, Fenchurch-st., *Lond.*, Stationer; for an improvement in the manufacture of paper. March 8. *For. Comm.*

20. John Shaw, Rishworth, *York.*, Bookkeeper; for improved machinery in preparing

wool, and also in preparing the waste of cotton wool for spinning. March 9.

21. George Bertie Paterson, Newington, *Surrey*, Engineer; for certain improvements in the construction of meters, or apparatus for measuring gas or liquids. March 14.

22. Thomas Theophilus Biggs, Queen Ann-st., *Middx.*, Esq.; for improvements in certain descriptions of fire-arms. March 17. In part *For. Comm.*

23. John Leberecht Steinhaeuser, Islington, *Middx.*, Merchant; for improvements in hand and power-looms. March 17. *For. Comm.*

24. Fletcher Woolley, York-st. East, Commercial-rd., *Middx.*, Gent.; for improvements in the manufacture or preparation of materials to be used as a substitute for bees' wax, parts of which improvements are applicable to other purposes. March 17.

25. Neil Snodgrass, Glasgow, *Lanark.*, Engineer; for improvements in steam-engines, and other mechanism of steam-boats. March 21. In part *For. Comm.*

26. Miles Berry, Chancery-la., *Middx.*, Patent Agent and Mechanical Draftsman; for certain improvements in cleaning, purifying, and drying wheat, and other grain or seeds. March 22. *For. Comm.*

27. Samuel Tonkin Jones, Manchester, *Lanc.*, Merchant; for improvements in the tanning of hides and skins. March 29.

28. Charles Brandt, Upper Belgrave-place, *Middx.*, Mechanist; for an improved method of evaporating and cooling fluids. March 31.

Total, March...14.

April.

29. Charles Pierre Devaux, *Lond.*, Merchant; for a new or improved apparatus for preventing the explosion of boilers or generators of steam. April 7. *For. Comm.*

30. William Hancock, Windsor-place, City-rd., *Middx.*, Gent.; for certain improvements in book-binding. April 8.

31. Richard Burch, Heywood, *Lanc.*, Mechanist; for improvements in locomotive steam-engines, to be used either upon rail or other roads; which improvements are also applicable to marine and stationary steam-engines. April 14.

32. Henry Backhouse, Walmsley, Calico Printer; and Jeremiah Grime, Bury, Engraver, both in *Lanc.*, for improvements in the art of block-printing. April 14.

33. William Nairne, Flax Spinner, Millhaugh, near Methven, *Perth.*; for improvement in the machinery of reels, used in reeling yarns. April 7.

34. Bennet Woodcroft, Mumps, *Lanc.*, Gent.; for an improved mode of printing certain colours on calico and other fabrics. April 18.

35. George Crane, Yniscedywyn Iron Works, near Swansea, Ironmaster; for an improvement in the manufacture of iron. April 26.

36. Nathaniel Partridge, Elm Cottage, near Stroud, *Glouc.*, Gent.; for an improvement in mixing and preparing oil paints, whereby a saving of ingredients commonly used will be effected. April 27.

37. James Hardy, Wednesbury, *Staff.*, Gent; for improvements in the manufacture of iron into cylindrical, conical, and other forms, suited for axletrees, shafts, and other purposes. April 27.

38. Christopher Nickels, Lambeth, *Surr.*, Gent.; for improvements in preparing and manufacturing caoutchouc, applicable to various purposes. April 29. In part *For. Comm.*

39. William Coles, Charing Cross, *Middx.*, Esq.; for improvements applicable to locomotive carriages. April 29.

Total, April—11.

May.

40. Moses Poole, Lincoln's Inn, *Middx.*, Gent.; for improvements in making fermented liquors. May 10. *For. Comm.*

41. Joseph Bunnett, Southwark, Window-blind Maker; for improvements in window-shutters, which improvements may also be applied to other useful purposes. May 12.

42. John Samuel Dawes, Birmingham, *Warw.*, Ironmaster; for improvements in smelting the ores or oxides of iron, copper, tin, lead, zinc, and other metals, and in remelting or refining the said metals. May 15.

43. Joseph Amesbury, Burton-crescent, *Middx*, Surgeon; for apparatus for the relief or correction of stiffness, weakness, or distortion, in the human spine, chest, or limbs. May 20.

44. John Gordon Campbell, Glasgow, *Lanark.*, Merchant; and John Gibson, of the same, Throwster; for a new or improved process or manufacture of silk, and silk in combination with certain other fibrous substances. May 20.

45. Henry William Crafurd, John-st., Berkeley-sq., *Middx.*, Commander R.N.; for an improvement in the coating, or covering iron and copper for the prevention of oxidation. May 22.

46. Charles Guynemer, Manchester-st. Manchester-sq., *Middx.*, Professor of Singing; for improvements in piano-fortes. May 24. *For. Comm.*

Total, May—7.

June.

47. William Bridges Adams, Bayswater, *Middx.*, Coach Maker; for improvements in the construction of wheels, and in wheel-carriages. June 2.

48. William Gossage, Stoke Prior,

Worc., Chemist; for improved apparatus for decomposing common salt, and for condensing and making use of the gaseous product of such decomposition; also certain improvements in the mode of conducting these processes. June 2.

49. **John Joseph Charles Sheridan**, London, *Middx.*, Chemist; for improvements in the several processes of saccharine, vinous, and acetous, fermentation. June 6.

50. **Pierre Bartlemy Guinibert Debac**, Brixton, *Surrey*, Civil Engineer; for improvements applicable to rail-roads. June 12.

ENGLISH.

N. B.—The first Date annexed to each Patent, is that on which it was sealed and granted; the second, that on or before which the Specification must be delivered and enrolled.——The abbreviation *For. Comm.*, signifies that the invention &c., is "a communication from a foreigner residing abroad."

June *contd.*

129. **Henry Augustus Wells**, Threadneedle-st., *Lond.*, Hat Manufacturer; for his improvements in the manufacture of hats. June 30.—Dec. 30.

Total, June...15.

July.

130. **Freeman Roe**, Camberwell, *Surr.*, Plumber; for an improvement in water-closets. July 7.—Jan. 7.

131. **John James Waterstone**, Millbank-st., Westminster, *Middx.*, Surveyor; for improvements applicable to the intercepting and directing of currents and waves of water. July 10.—Jan. 10.

132. **William Pringle Green**, Falmouth, *Cornw.*, Lieutenant R.N.; for improvements in capstans and machinery employed in raising, lowering, and moving ponderous bodies and matters. July 10.—Jan. 10.

133. **William Chubb**, Portsea, *Hants.*, Umbrella Manufacturer; for improvements in night-commode pans. July 10—Jan. 10.

134. **Thomas North**, Mitre-str., Newcut, *Surr.*, Card, Paper, and Metal Piercer; for an improvement in the manufacture of wire. July 19.—Jan. 19.

135. **Whitmore Baker**, Dedham, *Essex*, Veterinary Surgeon; for an instrument or truss, applicable to the nicking of horses' tails. July 19.—Jan. 19.

136. **John Pearse**, Tavistock, *Devon.*, Ironmonger; for improvements in the construction of wheels. July 19.—Jan. 19.

137. **John Hartley Hitchin**, and **Robert Oram**, Salford, *Lanc.*, Engineers; for improvements in the construction and arrangements of cranes for lifting and removing goods, by which such machines are rendered more generally useful. July 19.—Jan. 19.

138. **John Poad Drake**, Arundel-st., Strand, *Middx.*, Artist; for improvements in building ships, steam-vessels, and boats; and also in the building of canal and river barges and lighters. July 19—Jan. 19.

139. **Sir James Caleb Anderson**, Buttevant Castle, *Cork*, Bart.; for improvements in locomotive engines which are partly applicable to other purposes. July 19.—Jan. 19.

140. **Henry Goschen**, Crosby-sq., Bishopsgate-st., *Lond.*, Merchant; for improvements in preparing flat and hemp for spinning. July 19.—Jan. 19. *For. Comm.*

METEOROLOGICAL JOURNAL FOR JUNE, 1837; KEPT AT BLACKHEATH ROAD.

Day of Month	Barom. 9 A.M.	Ther. attch.	Barom. 3 P.M.	Ther. attch.	Thermometer		Daily Temp.	Solar Var.	Rad.	Clouds.		Winds		Direction of Wind		Luna-tion.	WEATHER, &c.
					Min.	Max.				A.M.	P.M.	A.M.	P.M.	A.M.	P.M.		
Thurs. 1	29·946	61°	30·010	61°	51°6	60°4	56°0	8°8	50°	7	5	3	2	W	NW		Squalls, with rain, till noon. P.M. fine.
Friday, 2	30·054	63	30·052	63	45·2	59·2	52·2	14·0	41	8	7	1	1	WNW	NW		Cloudy.
Satur. 3	30·002	63	30·004	64	46·5	60·6	53·5	14·1	44	10	3	1	0	NNW	NbE	●	Rain early, A.M. Fine Afternoon and Night.
SUN. 4	30·154	61	30·148	63	38·1	66·4	52·3	28·3	35	3	4	0	1	sly	SE		Fine; *cumuli;* Evening hazy.
Mon. 5	30·196	63	30·142	66	49·8	73·0	61·4	23·2	47	8	6	0	1	wly	SW		Hazy. Thunder to S. and E.; *cumuli*, and *nimbi.*
Tues. 6	30·150	67	30·166	67	50·5	64·9	57·7	14·4	48	3	2	2	2	NNW	NE		Harsh drying wind; Night clear and cold.
Wed. 7	30·234	64	30·164	65	40·8	56·5	48·6	15·7	40	5	0	2	2	NE	E		*Cumuli;* clear Night, and *sharp air.*
Thurs. 8	29·962	61	29·900	61	40·0	58·2	49·1	18·2	39	5	8	3	2	E	E		Windy and cloudy; *cirro-cumuli.* Evening overcast.
Friday, 9	29·825	64	29·720	67	47·8	72·0	59·9	24·2	47	7	9	1	2	ESE	ESE		Close; rain from 7 to 8, P.M.; mild windy weather.
Satur. 10	29·692	66	29·695	67	53·2	68·5	60·9	15·3	50	5	4	3	3	swbw	SSW		Blustering; flying clouds.
SUN. 11	29·825	66	29·852	66	53·5	67·0	60·3	13·5	52	4	3	3·4	3	swbw	WSW	☽	A gale for 36 hours, without intermission.
Mon. 12	29·984	66	29·940	67	48·0	68·5	58·3	20·5	46	7	8	1	2	S	SSW		Light rain; generally overcast.
Tues. 13	29·876	67	29·848	69	56·8	76·0	66·4	19·2	54	6	7	2	2	SW	SW		Fine warm day. *Scud.*
Wed. 14	29·830	68	29·900	69	58·6	74·2	66·4	15·6	57	9	5	2	1	swbw	W		Light rain at night. Cloudy; air soft.
Thurs. 15	30·048	69	30·024	71	50·0	78·1	64·1	28·1	48	2	1	0	0	sly	E		Very fine; *cumuli;* brilliant moonlight Night.
Friday, 16	30·002	70	29·942	72	54·7	77·0	65·8	22·3	53	8	2	1	2	E	E		*Stratus* till 9 A. M.; fine; rain at sunset.
Satur. 17	29·995	70	30·000	71	54·0	72·8	63·4	18·8	52	3	4	3	3·2	SW	SW		Flying clouds; windy.
SUN. 18	29·842	69	29·840	70	53·5	70·1	61·8	16·6	53	8	5	2	2	SW.N	W		Rainy till 10 A.M. Thunder at 1 P.M. to N.; fine Night.
Mon. 19	29·982	69	29·976	70	54·0	73·5	63·8	19·5	52	8	7	2	2	SSW	SSW	○	Cloudy. *Cirro-cumuli* in groups.
Tues. 20	29·980	68	29·949	70	50·9	76·5	63·7	25·6	48	6	6	2	1	SSW	SW		Ditto.
Wed. 21	30·060	70	30·125	71	54·5	73·5	64·0	19·0	53	8	3	1	1	W	SW		*Stratus*, A.M., into *cumuli;* fine Night.
Thurs. 22	30·348	69	30·348	71	50·0	73·4	61·7	23·4	47½	5	5	0	0	N	E		Hazy. *Cumulus.*
Friday, 23	30·401	69	30·370	70	50·2	74·0	62·1	23·8	48	0	2	1	1	E	E		Clear; a few *cumuli.* Horizon thick with haze.
Satur. 24	30·252	69	30·186	72	49·3	75·6	62·5	26·3	46	1	1	1	1	NE	E		Hazy. An *aurora* at midnight.
SUN. 25	30·136	70	30·116	73	51·5	77·1	64·3	25·6	49	0	2	2	2	NNE	NE	☾	Clear, A.M.; a few scattered *cumuli.* Clear Night.
Mon. 26	30·258	70	30·260	70	51·7	67·8	59·8	16·1	49	5	2	2	2	NE	NE		Cloudy, A.M. Afternoon clear, with wind.
Tues. 27	30·260	68	30·241	69	45·8	63·6	54·7	17·8	44	5	3	2	2	NE	ENE		Cold winds; thin *cumuli.*
Wed. 28	30·242	67	30·191	68	42·9	67·8	55·4	24·9	39½	4	1	1	1	NE	E		A few clouds, which dispersed about Noon.
Thurs. 29	30·190	68	30·125	69	43·2	73·2	58·2	30·0	42	0	0	1	0	NE	E		Thick *fog* and *stratus*, till 7, A.M. Clear.
Friday, 30	30·170	69	30·196	72	48·0	76·0	62·0	28·0	46	1	3	1	3	N	ENE		Strong drying wind. A turbid sky; flying clouds.
Mean	30·063	67	30·048	68	49·49	69.85	59.67	20·36									

Bar. Max. 30·401 in. on the 23th.
Bar. Min. 29·590 in. " 9th.

Ther. Max. 78·1° on the 15th.
Ther. Min. 38·1° " 4th.

Lowest point of Rad. 35°, on the 4th.
Rain fallen (by Crossley's self-registering gauge), 1·145 in.

ON THE VIBRATION OF GLASS VESSELS.

One of the most influential circumstances in retarding and discouraging the practical pursuit of science among the bulk of our fellow-men, is an unfortunate opinion that such investigations necessarily and imperatively require costly and elaborate apparatus: this opinion has been, in many instances, rather encouraged than discountenanced by selfish labourers in the field of science, who have thought such knowledge to be a patrimony belonging to the few, fearful lest the honour and credit accruing from scientific discovery should, by being shared among many, leave but a small modicum for each. Men, who are themselves bright stars in the intellectual firmament, have thought that, by shining alone, their own brilliancy is more conspicuous than when lesser stars claim a portion of the admiration. If personal exaltation were the end and aim of science, all this would be well; but as the advancement and well-being of the whole human family is the ennobling object which guides the inquiries of all rightly-constituted minds, we find that this prejudice is gradually wearing away, and that a love of the true and the beautiful, being strengthened by the very search after them, would be a probable result of placing in the hands of the many the means of performing experiments hitherto confined to the few.

We have on several occasions endeavoured to show that one chief object of the *Magazine of Popular Science* is to render the delightful field of experiment open to all lovers of nature, and particularly to such as are limited in means, either of a local or of a pecuniary kind. On a former occasion, we endeavoured to show that much melody might be derived from the skilful combination of a few drinking-glasses; and we then promised to pursue the subject, in order to show that much science may be learnt by the judicious employment of similar vessels: this promise we are now about to fulfil, and we propose to study, in two or three consecutive papers, the laws which regulate the vibration of glass and other vessels. The reader is therefore requested to provide himself with two articles, whose usual employments occur at times when people are least disposed to be philosophical; we mean, a common drinking-glass, or goblet, and a fiddle-bow.

In order to prepare the general reader to follow the rationale of experiments of this kind, it will be advisable to premise a few words on the acoustical laws which regulate the production of sound.

What are the wonderful bonds of connexion between the tangible material objects which surround us, and the sensations and ideas which those objects engender in the mind, is a mighty subject, which human sagacity will most probably never be able to penetrate. Physical effects on our sensorial organs are now much better understood than formerly, but how physical effects merge into mental perceptions, we must confess ourselves totally inadequate to explain. The last physical link in the chain to which our inquiries and experiments have extended, is the vibration of nervous filaments: how those vibrations give birth to mental phenomena, is a vast and unknown process; but how discouraging soever this limit to our present mundane faculties may appear, it should not prevent us from collecting all the information which research may afford, concerning the vibrations themselves, and the changes in our sensations which a given change in the vibrations are known to produce. We cannot tell what gravitation is, but we can measure changes in its intensity, brought about by given physical changes; and in like manner, although we cannot tell what sensation is, we can appreciate a difference between two sensations, the result of two physical impulses, which difference is within our power to calculate or to measure.

Sound, then, is the result of the vibration of nervous filaments contained within the ear; these vibrations are derived from similar vibrations of certain fluid, solid, and membraneous structures, which, in their turn, receive impulses from the surrounding air: if, therefore, the air be set into vibration by a spring moving backwards and forwards, or by a stretched cord, as of a violin, or by any other mode, those vibrations are communicated to the tympanum of the ear (a stretched membrane placed across the inner part of the passage of the ear), and from thence to the interior mechanism, where our power of analysis terminates.

By one vibration we mean a disturbance from the position of repose, and a regaining of the same position. Now it is found that nearly our whole knowledge of difference of sound results from difference in the rapidity with which the vibrations succeed each other, and that the only circumstance which stamps the difference between a sound and a musical sound is, that the vibrations which produce the former are unequal in their velocity, while those of the latter are isochronous, or equal-timed. When, therefore, the tympanum is struck by a single blow, which is not repeated, we hear a noise; when the impulse is repeated irregularly, the noise becomes a sound; but if the repetitions are *regular*, the sound assumes that character which we term musical. Nothing can be more illustrative of the simplicity of the processes by which Nature's handywork is carried on, than the really small, and often inappreciable difference, in manner or matter, by which entirely new characters are formed, as it were, out of old materials. Thus the slight changes which determine the characters of sounds, is a simple question of different velocities in the vibrations; and we find that the difference of *tone*, or pitch, depends on principles equally simple. We have said that a sound, to become musical, must be the result of isochronous vibrations, but these vibrations must not be under a given velocity; if they occur slower than sixteen in a second, the sound is not musical; but if they amount to sixteen, the ear appreciates a very deep musical tone; if now the velocity of vibration be increased, the tone is still musical, but becomes elevated in pitch, and a continual increase of velocity occasions a continual elevation of pitch. Thus, the only difference between the lowest and the highest note of a 5½-octave pianoforte is, that the one is produced from a string which vibrates, *i. e.*, strikes the air, about forty times in a second, while the vibrations of the other string amount to about 1400 within the same time.

This truth is general, and does not depend on the material or the form of the vibrating body, the mere velocity of its vibration being the circumstance to which tone is wholly indebted.

A stretched cord, and a glass goblet, are acted upon so differently by any force applied to them, that a slight analogy is all that can be drawn between them. It will, however, be useful to remark, that when a cord is stretched between two fixed points, and vibrated, the first and simplest method of vibration is to describe a curve, in its whole length alternately on both sides of the line of repose, or *axis* of the cord, the axis and the two curves being all in the same plane; this produces the *fundamental tone* of the cord.

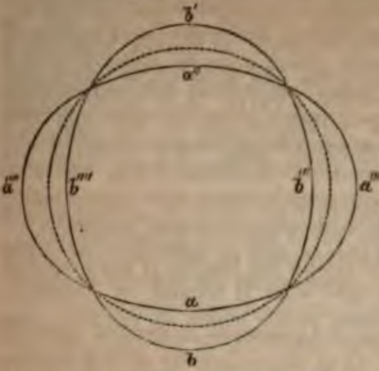
A more complex mode of vibration is, when there are certain points which never leave the axis, although the rest of the cord is freely vibrating; the relative distances of these points determine the lengths of the included vibrating portions, and those lengths have what is termed an *harmonic ratio*, or *proportion* to each other: those points which do not leave the axis are termed *nodes*, and the portion on either side of any one node, are on opposite sides of the axis with respect to each other, during vibration: each portion is termed a *ventral segment*, and its centre a *centre of vibration*. When, therefore, the axis of the cord vibrates, and is at the same time divided into separate portions, having a certain ratio in their lengths, and each portion vibrating in a system of its own, the resulting sounds are, *first*, a fundamental note due to the vibration of the cord along its axis, and, *second*, more acute tones due to the separate portions of the cord; and all these tones, by virtue of the ratio above mentioned, harmonize with each other, the acute tones being termed *harmonics*.

This being premised, we may consider it as a constant law, that when any body emits a musical sound, it is vibrating with great rapidity, and with exactly equal intervals between the vibrations.

Let us now take a common goblet, or drinking-glass, of any kind, and pass the moistened finger round its edge; we shall find a delicate and exquisitely pure musical note result therefrom, and that the note is, generally speaking, higher in pitch when the glass is either small in diameter or thick in substance, than when the opposite conditions occur. We may now ask two questions respecting these results; *first*, In what manner does the glass, being circular in its form, perform its vibrations? and, *second*, Why does a small or a thick glass emit a higher tone than one which is either larger or thinner? The answer to these questions leads us into a field of inquiry, rich in instructive phenomena, and one in which our readers could individually engage with little trouble, and with pleasurable as well as instructive results: but, in order the better to carry on the inquiry, it is desirable to employ a violin-bow, as, by its means, more vigorous vibration can be excited than by the finger.

If, then, we draw a violin-bow across the edge of a goblet, a soda-water glass, or any similar vessel, a musical note is elicited, which depends for its existence, as before stated, on a vibratory action of the glass itself; but in an empty and clean glass, we cannot *see* that it vibrates, whether the whole vessel oscillates to and fro on its leg, as an axis, as a flower or a tree does on its stem, or whether the vessel changes its form during vibration. We will proceed to show that the latter is the case, and that the glass, on receiving the first impulse, is thrown into

Fig. 1.



the form *a*, *a*, *a*, *a*, fig. 1, which, the instant afterwards is changed to the position *b*, *b*, *b*, *b*, the dotted lines being the position of the rim of the glass in a state of repose.

If we take four little pieces of thin wire, and bend them into the form of hooks, and hang them on the edge of the glass, so that one leg of the hook shall be within and the other without the glass, we shall find that they will be greatly excited during the vibration of the glass, excepting at four points of its edge, at which points they will be at rest, or nearly so: these four points are equidistant from each other, and it will be seen that the point to which the bow is applied is equidistant between two of them: if the hooks be placed at those positions at first, they will remain there, but if at other points, they will travel round to the resting-points.

Or we may take two pieces of thin wire, formed into the figure of a cross, the diameter of which is somewhat less than that of the edge of the glass, so that, when placed horizontally, it will sink a little way into the glass, and the four points rest against the sides; it will be seen that the glass, while vibrating, gives a trembling, shaking motion to the wire, which does not cease until the four points assume such a position that the place of the bow's application shall be between two of them.

A straight piece of wire, likewise, which is longer than the glass is high, may be rested, one end against the bottom, and the other against the top edge of the glass: this will be agitated in a similar manner, unless the top rest against one of the four points just alluded to.

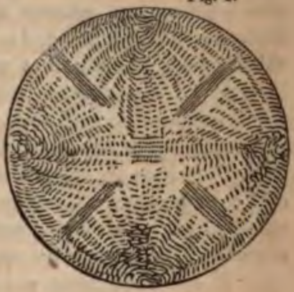
The existence of these four points is very pleasingly shown by the use of lycopodium, the seed of the *Lycoperdon bovista*, which possesses a degree of fineness greatly exceeding the generality of powders, each grain being, according to Wollaston, less that the 8500th of an inch in diameter.

For the use of this powder, a conical-shaped vessel is better than the shape of a goblet, but the latter will do. By sprinkling the lycopodium dust on the interior surface of the glass (to which a small quantity will adhere), and then vibrating the glass with a bow, a considerable portion of the powder will be shaken from off the surface, with the exception of four narrow lines of powder reaching from the top of the glass a considerable way down: in these lines there is very frequently not only the original portion of dust remaining, but an additional modicum derived from the other portions of the glass; and it will be always found, that the point to which the bow is applied (which, for convenience, we will call the point of excitation,) is always midway between two of the lines, thus preserving the analogy to the hooks and cross-wires. It is, moreover, singularly remarkable, that if the powder be sprinkled on the *outside* instead of the inside of the glass (care being taken to preserve the inside quite free from the powder), the same thing will occur; viz., four trains of powder will be seen passing down the *inner* surface of the glass: for this experiment a conical glass* must be employed, and with such a shaped vessel it will be found that a little tact will produce this paradoxical effect. It would appear that, during vibration, a portion of the powder is carried up by virtue of centrifugal force acquired by the glass, and which is stronger nearer the top than lower down, and that that portion passes over the edge, and settles down into four vertical lines. We will further allude to this mode of explanation presently, but the fact itself is independent of all theory, and is calculated to claim the notice of the experimenter very forcibly, as the transfer is instantaneous.

To these four modes of detecting the existence of vertical lines in the glass, having different properties from the remainder of the surface, we will now add another, which is, perhaps, more convenient in its application, and more appreciable; we mean, the presence of water, or any other liquid, in the glass. Water, coloured with litmus or ink to deaden the transparency, will answer very well.

If, when the glass is about half filled with water, it be vibrated by passing the moist finger round its edge, the liquid surface becomes broken up into a figure of four fans, which rotate in the direction and with the velocity of the finger, the latter being always midway between two of the fans, its pressure causing the point on which it rests at any given instant to assume the condition of a node; but if the glass be excited to vibration by means of a bow, the surface of the water is thrown into the form represented by fig. 2. From four equidistant points of the glass emanate four fans of liquid undulations, which proceed nearly to the centre of the liquid surface; and it is seen that, whatever part of the glass be chosen as the point of excitation, one of the fans emanates from beneath that point. The oblique action of two contiguous fans raises a faint ridge, which proceeds from each node to the centre; while the extreme ends of the four fans form, in meeting at the centre, a net-like figure, which is generally that of an imperfect square.

Fig. 2.



The last corroborative evidence of the existence of these four remarkable points in the circle of the glass which we shall mention, is obtained by the use of any oily or viscid fluid, such as is calculated to adhere to glass more than water does. If the vessel be half filled with such a liquid, (care being taken to preserve the inner surface of the glass, between the oil and the rim quite dry,) and vibrated by one rather decided stroke of the bow, it will be seen, on viewing the glass horizontally, that four vertical curves are formed by an upward starting or motion of the oil in four places, by which a small stratum is left adhering to the surface of the glass, and, in analogy with previous instances, the point of excitation occupies a position immediately over the highest point of one of these curves.

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* A conical wine-glass will do, and if the glass be blue or green, &c., the effect will be more striking, inasmuch as any figures formed within the glass are more striking from the contrast of a light-coloured powder upon a dark ground.

Here, then, we have obtained six different modes by which we learn that, during the vibration of the glass, there are four equidistant points round its surface which produce an effect on any solid or fluid bodies in contact with the glass, different from that produced by the remaining portions of the surface, and as we have no reason to believe that that property resides inherent in the glass, considered by itself, we have to determine how its manifestation is brought about by the influence of vibration; and to that point we will at once proceed.

The first impulse of the bow draws the part of the glass to which it is applied out of its original position, which we will term the circle of repose: if, however, that were to occur without a displacement of the other portions of the glass, we should obviously have a circumference of glass greater than that of the original circle: this kind of stretching is, however, opposed by the great compactness of the substance of the glass, and in order to allow the point of excitation to recede further from the centre, the adjacent sides of the vessel approach nearer to the centre; but as this inward impulse proceeds from two points instead of one, it is double in intensity when compared with the primitive impulse which it was intended to correct: it therefore thrusts out the part opposite to the point of excitation, in order to restore equilibrium. It will now be evident that we have obtained a figure exactly analogous to that of an ellipse: that is, the same quantity of glass is arranged into a regular curve, of which four points are at their original distances from the centre, two segments at greater distances, and two other segments at a less distance, such as in fig. 1. The rapidity with which this transformation takes place is such that we may call it instantaneous, but it is more instructive to proceed by steps such as we have attempted, by which we may conceive that while one segment is thrust outwards, two other segments are drawn inwards, to compensate the disturbance; but in so doing, produce an effect more than sufficient for the required purpose, and thus produce an opposite disturbance, which requires for its equalization that a fourth segment should be thrust outwards, which fourth segment is diametrically opposite to the segment first excited.

If the reader has now succeeded in forming a clear conception of the manner in which the primitive impulse of the bow transforms the figure of the glass from a circle to an ellipse, he will find the subsequent part comparatively easy. When the impulse has produced the greatest displacement of which it is susceptible, a momentary state of rest occurs, in which the glass is elliptical; but its elasticity will not permit a continuance in that form; the depressed portions acquire an outward tendency, and the elongated portions a tendency towards the centre; there must therefore be points where these opposite tendencies neutralize each other, and those points must necessarily be the parts of the glass which were not originally disturbed from their position of repose.

There is scarcely an instance in physical science of a dynamic impulse losing its effect at the precise point of compensation. A pendulum, if moved from the perpendicular, returns thereto by virtue of the force of gravitation; but not only so, it passes its original boundary, and assumes a position on the other side of the perpendicular: so it is with the four segments of the glass; by the time they have regained their original position, they acquire a momentum which carries them beyond the circle of repose, the two outer segments passing within, and the two inner segments passing without. A moment's consideration will show that this action must generate an ellipse, of which the longer axis is at right angles to the longer axis of the former ellipse *a*, *a*, *a*, *a*, which it has just superseded: this we may represent by the ellipse *b*, *b*, *b*, *b*, fig. 1.

It will now be well understood that the same causes which produced the destruction of the first ellipse will act with equal force on the second; elasticity will carry the displaced segments back to their original positions, and in so doing will generate a momentum sufficient to carry them beyond that boundary, and thus give rise to the formation of an ellipse similar to the first, and at right angles to the second. Thus these reciprocations succeed each other until the resistance of the air and other circumstances finally, but gradually, subdue them; for it should be understood that each successive ellipse is less elongated than the preceding.

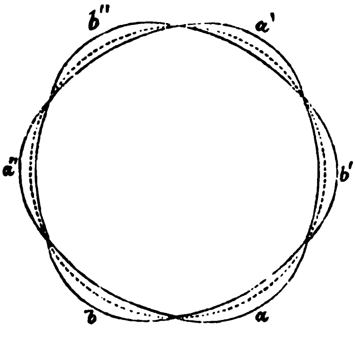
The description of these changes necessarily takes a considerable time, but the changes themselves occur with almost inconceivable rapidity, being several hundred times in a second; and as our visual powers are quite inadequate to detect the individual links in such a rapidly-recurring series, whatever effect either ellipse considered separately is calculated to produce, we estimate the result as if both ellipses were co-existent; and this will now enable us to explain the quadripartite phenomena before described. If water be contained in the glass, the transformation of the latter from a circular to an oval form necessarily occasions a flow of water from the flatter towards the smaller ends of the ellipse: when the latter is reversed, a flow occurs in the opposite direction, and as the eye cannot detect any interval of rest between the two, an impression of their simultaneous existence is left upon the mind. Thus the form of fig. 2 is presented to us, and thus shall we be enabled to apply the same mode of reasoning to the points of rest indicated by the hooks, wire, &c. While the four segments of the glass are rapidly vibrating to and fro, the four intermediate points, being urged both ways as it were, do not move at all, and any bodies placed against those points will be nearly as quiescent as if the glass were not vibrating: thus, if the little hooks be symmetrically placed equidistant from each other, and the bow be applied midway between two of them, the two consequent ellipses will cut each other at the points on which the hooks are placed, and then those points become nodes or quiescent points which are not likely to disturb the hooks placed upon them; but if the latter be placed at other points, or if the bow be applied other than midway between two of them, the hooks partake of the vibratory action of the parts of the edge on which they are resting, and are gradually shaken to those points where the agitation is less vigorous, and finally attain the nodal points.

The same reasoning applies to the cross-wire, the four points of which are affected or non-affected with tremulous motion, according as they happen to rest against vibrating or against nodal portions of the glass. Again, the wire reclining against the upper edge of the glass, is influenced precisely in the same manner.

With respect to the lycopodium dust, it is evidently shaken from those parts which are actively vibrating, because its adhesion to the glass is very slight; but as there is no motion occurring at the nodes, there is no reason why it should be removed from thence, and we consequently find that a line of powder remains on the quiescent points: it must here be remarked that although, for convenience, we have spoken of the glass as a vibrating circle, the effect is obviously carried a considerable distance towards the bottom, and, instead of nodal *points*, we have nodal *lines*, down which the powder remains undisturbed. Thus may these interesting phenomena be analyzed, and the rationale of their production traced step by step; but the inquiry by no means stops here: we have treated of that combination of circumstances which will induce a system of four vibrating segments in the glass, but we shall find that the same principle, modified in its individual application, is discernible under other conditions, into the consideration of which we will now enter.

We have stated that when the original impulse drew the point of excitation and an adjacent portion on either side out of the original position, two lateral segments were impelled nearer to the centre, to institute a balance of forces, but whether those shall be at right angles to the original impulse will depend upon the intensity of the latter: the elasticity of the glass is a constant quantity, therefore if the force to which it is opposed be variable, the resulting effect will be variable: when, therefore, the bow is drawn forcibly across the edge of the glass, the latter is allowed a wider range of displacement before the elasticity produces a compensation, than when the impulse is less forcible; and in order that the segment may recede further from the centre, a larger arc of glass is included within its range.

Fig. 3.



If, then, the impulse given by the bow be less energetic than that which produced the effects before described, there exist good reasons for believing that the glass assumes a form analogous to *a*, *a*, *a*, fig. 3. Let us suppose that the bow is applied at the point of the glass marked *a*: a segment is drawn out of the circle, as before, but by the time the impulse reaches the nodal points on either side of it, the elastic tension urges the two adjacent portions, *b*, *b*, within the circle, to restore equilibrium: these three segments together take up a semicircumference which acts upon the opposite semicircumference by momentum, thus:—the two lateral segments, *b*, *b*, by passing too far towards the centre, induce a protuberance in the more remote portions, *a'*, *a''*, which, in their turn, generate a third depression at *b''*; thus, then, we obtain three segments exterior and three interior to the original circle of repose, which give to the periphery, taken as a whole, the form indicated by a, a', a''. Let us now bear in mind the manner in which one ellipse gave rise to another ellipse which immediately succeeded it, and we shall have but little difficulty in concluding that the same principles will convert the heart-shaped figure, a, a', a'', into a similar figure, b, b', b'', the elongations of the former coincide radially with the depressions of the latter, and the depressions of the former with the elevations of the latter. There will be obviously in this case six points where the two superposed figures cut each other, and these points, from the principle before alluded to, will be at rest.

This, it will be observed, is a theoretical deduction of what would occur if the primitive impulse were not energetic enough to draw a quarter of the circle out of the position of repose; but we will now proceed to give practical illustration of the existence of these three-sided figures.

In drawing the bow across the edge of the glass, it will be found that more than one sound can be heard; frequently four or five; all musical and rich, but all different in pitch. If now, by the presence of water in the glass, we obtain a figure of four undulatory fans on the surface, we shall invariably find that the musical note elicited at that moment is the lowest in point of pitch of all those which it is capable of producing; and as the surface is never broken up into a less number than four vibrating segments, and four nodes between them, it will be convenient to call the musical note produced at that moment, or by that mode of vibration, *the fundamental note*. If now we draw the bow smartly across the edge of the glass with a motion which may be called quick rather than forcible, we shall obtain the next higher tone, and at that moment the liquid surface presents six vibrating fans of undulæ, equidistant from each other, and separated by six points, where comparative quiescence is observed.

We may now, without any forced analogy, at once refer the formation of this six-sided figure to the superposition of two similar three-sided figures, whose origin we lately discussed. The impulse at the point of excitation is not sufficient to draw a quadrant of the circle out of its original position, its power being limited to an arc of about 60°; two adjoining sextants or sixth parts are by that disturbance thrust inwards; two further remote portions follow the course of the first, and the last sextant is in an opposite state to the first; thus originates the three-sided figure, the duplication of which, produced by all the six segments changing their conditions, conveys the idea of a simultaneous existence of six vibrating segments, as indicated by six fans on the surface of the liquid.

All the modes by which the nodes were detected when the elliptical figures were produced, are equally available in the present instance; the hooks, wires, lycopodium, &c., indicate the existence of six points, or vertical lines, as the case may be, in which no vibration is going forward.

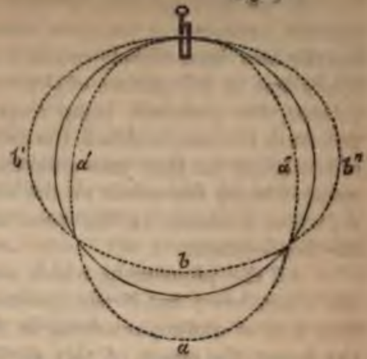
With a slight modification of the mode of handling the bow, which it is difficult to describe, we can next produce a tone higher in pitch than that which accompanied the six-sided figure; and the invariable result will be a figure of eight sides, that is, eight liquid fans of undulæ will emanate from the sides of the vessel towards the centre of the liquid, and be separated from each other by nodal lines as before. The reader will not require that we should retrace our steps in detailing the production of this eight-sided figure; a due appreciation of what has been already said will render a brief description sufficient for the present purpose. The impulse communicated by the bow is still less energetic than that last spoken of, and only sufficient to influence an arc of 45° of the circle of glass. This arc is generated in a manner exactly analogous to the preceding instances; alternations of excursions and incursions all round the glass, eight of such arcs or segments completing the circle, four being without and four within the circle of repose. At this moment, the figure approximates roughly to the form of a square, the middle of each side of which is nearer to, and each corner further from, the centre of the glass than when it has its proper circular form. If now the corners and sides of this square become transposed, (which they do through the influence of elasticity,) we obviously obtain an eight-sided figure, the cutting points of the two superposed figures forming the nodes as before. It must be remembered that, when we say this note is invariably accompanied by a figure of eight sides, we mean that the note is the next higher in pitch to that which produced the six-sided figure; and in further evidence of the same fact, it will be found that the fourth tone which the glass is susceptible of producing will always be accompanied by a figure of ten sides, whether the indicator employed be water, lycopodium, or wire.

Generally speaking, not more than four different tones can be elicited from any one glass; sometimes, however, a fifth is appreciable; but be the number what it may, the vibrating segments and nodes always increase in number by twos as the elevation of pitch increases, they being 2, 4, 6, 8, &c.

A very remarkable and instructive effect is however produced when the edge of the glass is at any one point prevented from vibrating freely: a violin performer is well aware of the effect resulting from placing a sourdine or damper on the bridge of his violin,—the tone acquires a peculiar and subdued character, from the circumstance of the vibration of the bridge upon which the strings rest being interfered with. In like manner, any small instrument which would act as a damper when placed on the edge of a glass, interferes with the production of those effects which naturally result from the free and unshackled vibration of the glass. We have employed a small steel instrument which clasps the edge by means of a screw, but other modes may be devised, provided that the damper where it clumps the glass presents a certain amount of plane surface, probably not less than a tenth of an inch.

When an impediment to free vibration, such as this, is employed, that force of vibration which would otherwise produce a four-sided figure, or one composed of two superposed ellipses, will produce but three vibrating segments, one of which is diametrically opposite the damper, and the other two so situated as to form with the third nearly an equilateral triangle, *provided* the bow be applied immediately opposite to the damper; but if it be applied at about 45° on either side of that point, *four segments* will be formed just the same as if no damper were placed

Fig. 4.



on the edge. The rationale is this; the original impulse influences a quadrant (*a*) fig. 4, of the circle, as if no damper were used, and the adjoining segments, a' a'', on either side, are drawn or impelled inwards, in accordance with the elastic tendency; but the third step in the process,—the generation of a fourth segment opposite to the first,—is prevented by the presence of the damper, which will not permit vibrations to occur at the part where it is placed[*]. The consequence is, the impulse is expended in the production of the two depressions a' a'', without producing the fourth segment opposite to the first. Thus there is only one part of the glass exterior to the circle of repose, while there are two parts within that circle, the consequence of which is, that when the elasticity has reversed the positions, there result two parts, b b'', exterior, and one, b, interior to the circle: the rapid superposition of these two figures present the three excursive segments at apparently the same moment, and thus the triangular form is accounted for. When, however, the bow is so applied as to allow the damper to occupy the place of a node, no interruption is experienced in the vibration, and all four segments are produced.

If any of our readers repeat the above interesting experiment, it will be seen that the fan *a*, (fig. 4,) is larger in size than the other two fans, and the splashing of the water will indicate greater activity of vibration at that arc; now, as the action of the bow elongates the circular rim of the glass into an ellipse, only *one end* of which is beyond the circle of repose, (the damper retaining the other in its place,) its rebounding energy being thus concentrated, as it were, in one vibrating arc, carries it so far towards the damper, that it expends its force by thrusting out of the circle of repose the glass at b' b' on both sides of the damper, and as near to it as its inertia will permit; there are then, at the second half of each vibration, two portions exterior to the circle of repose, but as b' b'' have to share between them the impetus received from *a*, that reasonably accounts for the discrepancy between the sizes of the fans at *a* and b' b''. The efforts, again, of b' b'' to regain the circle of repose, produce their combined effects on *a*[†], which shows the extent of that combination by being further from the circle of repose than b' or b''; thus do the oscillations continue, and thus does a superposition of two like figures satisfy the conditions of a ter-nodal division, as well as that of an even number of nodes.

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[*] The damper does not act so much (if at all) by its weight, as by its tendency to flatten the curved surfaces of the glass against which it presses, so as to produce that rigidity which is the necessary result of a highly-elastic body being permanently held out of equilibrium.

[†] The excursions of the vibrations at *a* are sometimes so great as to fracture the glass at that part, and it has happened to the writer with a slim glass, that the whole sector, *a*, came out, and the remainder of the glass was preserved entire.

If we now produce all the other tones of which the glass is susceptible, retaining at the same time the damper on the edge, and applying the bow immediately opposite to it, we shall find that the number of ripply fans on the surface of the water is one less than if no damper were present, the numbers being respectively 3, 5, 7, 9, &c. It is not now necessary to trace in detail the causes of this; precisely the same mode of reasoning as that just adopted will avail for all, the difference of number being dependent on the difference of energy in the first impulse, or, which amounts to the same thing, the extent of curve included in the first segment.

All the phenomena which we have been detailing are produced by the violin-bow; but if the moistened finger be employed, we perceive four fans of undulæ revolving in the direction, and with the velocity of the finger, the reason of this revolution is, that, as fast as a vibrating segment is produced by the friction of the finger, it is interfered with by another formed by the finger at the succeeding moment a slight distance from it; and thus new segments are continually forming, which give a rotatory appearance to the surface of the liquid.

With respect to the musical tones elicited from any one glass, it is rarely found that they harmonize with each other; the intervals between them varying from three semitones to an octave. The marked difference observable in this respect is due to a combination of causes: first, the thickness of the glass compared with its diameter; secondly, the perfect or imperfect circularity of its form; thirdly, the amount of equability in the thickness of the glass at every part of the circle. All these circumstances modify the tone produced.

It is desirable here to consider a little more minutely the effect of thickness of substance in determining tone: we commenced our inquiry with two questions—"How does a glass vibrate?" and, "Why does a large or thin glass emit a deeper tone than one which is either smaller or thinner?"

The first question we have already answered: a glass, in vibrating, changes its form into an elliptical or into a three, four, or five-sided figure, according to the tone produced. This figure is succeeded by one similar to it, but not coincident with it, and the rapid reciprocation of these two superposed but not coincident figures constitutes the vibration of the glass.

The second question finds its answer in the circumstance that the more matter which is congregated in a given space, the larger is the amount of elasticity possessed by it as a whole; and, as a necessary consequence, the more energetically does it resist any disturbing influence from without. When, therefore, we have two glasses equal in diameter, and unequal in thickness, a quadrant of the thicker glass possesses a stronger elastic power than a quadrant of the thinner glass, and by its influence returns, after any disturbance, more rapidly to its position of equilibrium. Supposing, therefore, that the violin-bow produce equal displacement in both quadrants, the thicker of the two will rush back to its normal position more quickly than the other, and thus the vibrations which are nothing more than reiterated attempts to regain its original place, will be more rapid; and as elevation of pitch is dependent on rapidity of vibration, the tone elicited from the thicker is more acute than that from the thinner glass.

If the two glasses be equal in thickness but unequal in diameter, the higher tone of the smaller glass is due to the smaller extent of the quadrant of its circle, the thickness being equal. The ratio between the length of the curve and its thickness determines the tone; for the nearer that ratio is to unity, or, in other words, the nearer the two quantities are to equality, the more rapid will be the vibration. In the large glass, therefore, the curve being longer without being thicker, the two dimensions are more unequal than in a small glass; the vibrations are slower and the tone deeper. If the thickness of two glasses were in the same ratio as the diameters, they would, *cæteris paribus*, emit the same tone. Should the circle be imperfect, or the thickness not equal in every part of it, discrepancy in vibration must result.

In a second paper we will treat of the effect which a damper or any other obstruction of a similar kind has in lowering the tones, and will endeavour to show that a little spark of the soul of music resides in substances which have obtained a sad character in the world's estimation for anything like musical purposes, such as lead, wood, &c.

ON DIETETIC CHEMISTRY.

VI.

The principal object of the preceding papers on Dietetic Chemistry, has been to direct the reader's attention to the nature, sources, and properties of the elementary forms of matter employed in the production of organized substances, and of those proximate principles, or resulting compounds, derived from the vegetable and animal kingdoms, which are in common use as articles of food. In the former list, namely, that of ultimate elements, are included carbon, hydrogen, oxygen, and nitrogen; and in the latter, or that of proximate elements, we have starch, gum, sugar, and gluten, derived from vegetable organization, and gelatin and albumen from animals, together with oil or fat, which may be said to be common to both. This short list includes our essential nutriment, modified, however, and in many cases *materially* modified, by culinary operations, and aided by condiments, by astringent and aromatic substances, and by certain stimulants which are the products of fermentation, such as beer, wine, and spirituous liquors.

We have also noticed the analogies which subsist between vegetable and animal food, and the gradual manner in which the products of the two animated kingdoms of nature, like the individuals which constitute their genera and species, merge into each other. The gluten, for instance, of wheat, the albumen of the cruciform plants, and some other vegetable principles, resemble animal matter in their composition, properties, and nutritive powers; while, on the other hand, the various forms of oil and of fat are, as it were, common to both; and in milk, we find a substance (sugar of milk) identical with the products of vegetation, and which, were its source unknown, would be considered as a vegetable product.

Lastly, we have seen the mutual dependence of the organized kingdoms, and of their individuals, upon each other, drawn from the necessity of organic products for the continuance of living powers; even the lowest tribes of vegetables can only continuously subsist upon the matter which has at one time or other been subjected to organic laws; and although vegetables possess to a greater extent than animals the power of consolidating or appropriating the elements of air and water, they still require, in addition to those sources of nutriment, something which has at one time or other appertained to living matter. Throughout the animal kingdom, the same law of nutrition more remarkably prevails; the necessity of highly organized products for sustenance becomes then more apparent, and, as regards ourselves, a mixture of animal and vegetable food, aided by cookery and by condiments, may be said to be essential to our well-being and to our social existence; for all attempts which have been made materially to simplify our diet have not been attended by any flattering results, nor have either philosophers or economists succeeded in persuading mankind, either by example or precept, that raw vegetables and water are conducive to health and longevity, so that man must still submit to the distinctive definition of being a *cooking* animal*.

With the preliminary information now before us, the *theory* of the process of assimilation, or of nutrition, is perfectly intelligible. It consists in a power appertaining to living organs, of so recombining the elements of organized matter, as to form parts of themselves; for it will be apparent by reference to what has already been stated, that living and dead matter, as far as gross and ponderable components are concerned (that is, excluding ethereal or imponderable agents), are similarly constituted, and that, as far as our proofs go, the vital organs have no power of transmuting one element into another, nor of producing or evolving any new elementary forms of matter. Yet, the living body is indisputably endowed with *peculiar* chemical powers and characters; and the elements, whilst under the influence of vitality, are obedient to most singular and characteristic laws: or, in other words, composition remaining the same, the chemical habitudes of the same substance when alive and when dead, are essentially and widely distinct. Among these, the most remarkable in reference to the mere chemistry of the question, are the tendency of living matter to preserve its integrity of composition, to resist change, to remain unaltered and undecomposed under those very circumstances which otherwise tend to hurry it on to decay and decomposition. So, when either a part, or the whole of the body, is deprived of that mysterious influence which we call *life*, all its chemical habitudes and relations are immediately changed, and, without any other apparent cause, it loses its power of self-preservation, becomes obedient to the ordinary chemical laws of nature, and hastens to arrange its elements under those forms, and in those proportions, which characterise *inorganic* compounds, and to the distinctive differences of which we have elsewhere alluded.

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* The evidence adduced before the Poor-law Committee of the House of Commons furnishes some melancholy corroborations of the above view, and shows the influence of want of proper and sufficient nutriment upon the corporeal and mental faculties.

Though the essence, or first cause of life, must of necessity remain hidden from limited vision, it is not so with regard to its concomitants and effects; these, the anatomist and physiologist have divulged, and wonderful are the results of their disclosures. To such of these as bear upon chemistry, that is, to a few points of *chemical physiology*, we may now briefly advert.

The history of the nutrition of vegetables is simply this; they absorb those forms or combinations of carbon, hydrogen, oxygen, and nitrogen, which are requisite for their increase and support, partly by their roots from the soil, and partly by their leaves from the air; and these they remodel and recombine in their various cells and vessels, rejecting what is superfluous or noxious, and producing, in their wonderful laboratory, from such apparently intractable and unpromising materials, that wonderful diversity of secondary products forming perfumes and poisons, or fitting them for the food of animals and the sustenance and luxury of man.

In regard to animal nutrition, the distinctive character between animals and vegetables is founded upon the *stomach* of the former; instead of absorbing food by the surface, they have a distinct organ for its reception. Without, however, even mentioning the infinite varieties and structures of that organ in the different tribes, we may briefly notice the business and duties which it performs with ourselves.

Our food, when duly masticated, and largely mixed with the secretions of the mouth, is transposed, by most admirably contrived mechanism, into the left extremity of the stomach, and is there gradually *digested*, and, as it were, dissolved, by the extraordinary powers of the gastric juice; that is, of a secretion peculiar to the stomach, the solvent powers of which over certain forms of organized matter is such, that were it not protected by *life*, the stomach itself would be its first victim: there, again, *vitality* interferes; so that it is necessary, before anything can be digested, that it should be *dead*, and it is then gradually dissolved, and ultimately, by the powers of the stomach, and the adjacent and auxiliary viscera, reduced to the condition of a milk-like fluid, called *chyle*, which is the intermediate state between the crude contents of the stomach and the *blood*, the ultimate formation of which, as being the fluid from which all other parts of the body are elaborated, is the great object of the complicated machinery and processes to which its materials are subjected. But we find nothing in the blood which is not found in our food, so that although the identity of our food is destroyed in the stomach, destruction goes no further. The chief ultimate components of the blood are carbon, hydrogen, oxygen, and nitrogen, and these are also the ultimate elements of our food; so that to understand how digestion effects the nutrition of the body, we must endeavour first to ascertain what chemical changes go on in the stomach itself, then examine the nature of the blood, and lastly look into the phenomena of that wonderful process called *respiration*, in which the blood throws off part of the surplus and useless materials of the body.

Very little is known respecting the chemical functions of the stomach, that is, of their *cause*. We know that the gastric juice is always sour, and that muriatic acid, and either lactic or acetic acid are present during the digestion of food. This existence of muriatic acid is a curious and interesting fact; more or less *salt* seems essential to digestion, and it is probable that this is the source of muriatic acid; hence also, perhaps, the soda of the blood.

There is another unaccountable peculiarity in the stomachs of all animals, which is the power of coagulating albuminous liquids, and especially milk, which as soon as it enters the stomach is converted into curd and whey; hence the use of *rennet* for that very purpose. It is an effect not due to acids merely, for a morsel of rennet will coagulate a large quantity of milk; the cause of the coagulation is not further understood. In all cases of albuminous food the albumen is first coagulated, and afterwards liquefied or dissolved by the agency of gastric juices.

If we now consider the chemical composition of the blood*, we shall find, that although complicated by a multiplicity of salts, all and each of which are doubtless there for some particular purpose, one of its leading ingredients is albumen; and, what no doubt is remarkable, of that other proximate principle, *gelatin*. There is also an extraordinary *colouring matter*, the nature of which is but imperfectly understood, but we know that all acids render it nearly black, and that neutral salts redden it and render it florid: now in the *veins* the blood contains *carbonic acid*, which there blackens it, and which is got rid of in its passage through the lungs, that is, in *respiration;* the carbonic acid is there thrown off, oxygen is absorbed, and the blood passes from the black to the red state, and with its change of colour, and its loss of carbonic acid, it acquires the wonderful power of stimulating the brain to its due actions, and of forming and reproducing the different parts of the body; for in this respect, the blood performs a double duty—it is continually furnishing materials for the formation of new organs, and as constantly carrying away the old, and this process of secretion or deposition, and of removal or absorption, is always going on in the living body, so that no part is durable, constant, or permanent; but the very essence of vitality is, that every part is in a state of perpetual change, and the moment this activity

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* To give the reader an idea of the complex nature of the blood, we subjoin the following quantitative analysis of that fluid, by Lecanu, premising that the colouring matter includes a principle closely allied to albumen:—

Water - - - - - - -	780·145
Fibrin - - - - - - -	2·100
Colouring matter - - - -	133·000
Albumen - - - - - -	65·090
Fat - - - - - - -	3·740
Extractive - - - - - -	1·790
Albumen combined with Soda - -	1·265
Chlorides of Sodium and Potassium Carbonates Phosphates of Potassa and Soda Sulphates	- 8·370
Carbonate of Lime and Magnesia Phosphate of Lime, Magnesia and Iron Peroxide of Iron - - -	2·100
Loss - - - - - - -	2·400
	1000·000

ceases, the part dies. As, therefore, on the one hand, our food is converted into blood, and so furnishes materials for this constant regeneration, so, on the other hand, the blood is also the channel by which the useless materials are carried away and sent out of the system, partly in the form of excretions, and partly by the lungs; as far as concerns the latter, this wonderful process is termed *respiration;* the moment it ceases, we die; and if it be only suspended for a short time, we faint and become insensible, because, among other reasons, the carbonic acid is retained in the blood, and is, when so retained, a powerful narcotic poison*. The chemistry of respiration, therefore, comes next before us.

Respiration consists in the reception of atmospheric air into the lungs, and its subsequent *expiration*. Atmospheric air is a mixture of about 20 parts of oxygen and 80 of nitrogen (by measure), and it always includes moisture, and *traces* of carbonic acid. When the air is ejected from the lungs it is loaded with aqueous vapour, and includes from 3 to 5 *per cent.* of carbonic acid gas, so that carbonic acid and water are thus thrown off, and, perhaps, a little nitrogen; and it is probable that this carbon is derived from the old materials of the body, whilst our food is supplying their place. The quantity of carbonic acid thus evolved, varies with varying causes; it is greater during digestion, or at least during the conversion of chyle into blood, and least during abstinence from food; but upon the lowest calculation it appears, that, in the adult at least, the proportion of carbon thus thrown off from the system, is nearly equal to that which is contained in our food†. The bulk of carbonic acid produced by a healthy adult individual in the course of twenty-four hours, amounts probably to about 15,000 cubic inches, containing about 2600 grains of carbon. How or where the carbonic acid is formed, is not, perhaps, exactly known, but of its formation, and of its emission in the lungs, there can be no doubt, nor of the highly important ends attained by its emission, as well as that of aqueous vapour.

Let us now, then, look at the wonderful provisions which nature has made for the further uses of this load of carbon which we are thus throwing into the air, and which amounts to about six ounces from each individual in the course of twenty-four hours, or to between 37 and 38 pounds from every hundred persons; so that (assuming 37 lbs. as the average), a million persons would thus throw off into the air about them, no less than 370,000 lbs., or upwards of 165 tons of solid charcoal[*]. If there were not excellent and adequate adjustments which compensate for and virtually remove this poisonous effluvium, for so, in fact, it may be called, in reference to the above-mentioned effects of carbonic acid upon the human system, it would soon overwhelm and annihilate us. Now these are, in the first place, its *gaseous state*, by which wings are, as it were, given to it, and it is wafted away the moment that it escapes from our lungs, *ascending* into the air[†], and, in consequence of another wonderful property of gases, presently blending itself with the enormous mass of our atmosphere. In the next place, this carbonic acid, which is poison to us, is the food of plants, and of the whole vegetable world; they absorb it into their systems, and whilst they retain the carbon they emit the oxygen, and so, feeding themselves, they purify our atmosphere. Here, then, we have disclosed to us the mutual dependence of the animal and vegetable kingdoms; the manner in which the latter drink in the dew, and absorb the carbonic acid of the air, consolidating both in their admirable structures, producing thousands of new forms for the support of animals, contributing also to our mental gratification, by their verdure, their beauty, their variety, and their fragrance; and by the wonderful book of knowledge which they open to the physiologist; and passing through graminivorous tribes into forms destined for the food of man, they accomplish that wonderful circle which was drawn in our first essay, and of which we have now traced the circumference.

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* The noxious effects of carbonic acid are very peculiar; if we attempt to take it into the lungs in a pure, or nearly pure, state, it causes immediate *suffocation*, inducing spasms of the epiglottis, and killing by exclusion of air, and not by any direct effect upon the blood. Miners and well-diggers know it under the characteristic name of *choak-damp;* but when carbonic acid is largely diluted with common air, it operates as a powerful narcotic or stupifying poison. The effects are described at length by writers upon toxicology. Hence the danger of charcoal fires in ill-ventilated rooms, and the frequent cases of death that have occurred by breathing air more or less so contaminated. (See CHRISTISON, on *Poisons.*)

† It has already been remarked, that of our solid animal food, such as meat, fish, &c., about three-fourths consist of water; the residuary and really nutritive portion contains about half its weight of carbon. Messrs. Allen and Pepys have stated that the weight of the carbon daily thrown off by the lungs exceeds 5000 grains; this is nearly one troy pound, and would require for its production about six pounds and a half of solid food to be taken daily, which is probably about double that which falls to the share of an ordinary eater. Messrs. Allen and Pepys probably assumed the *maximum* of the evolved carbonic acid as the foundation of their estimate, and as we make about 26,000 respirations in the course of twenty-four hours, a very slight error of calculation in regard to a single respiration would, when so multiplied, be of large amount.

It has been well and wisely observed by an eloquent statesman, that the highest of all our gratifications in the contemplation of science, is that of raising us to an understanding of the infinite wisdom and goodness displayed in the works of the creation; showing us at every step the most extraordinary traces of design, and enabling us to follow, as it were, with our own eyes, the marvellous works of the great Architect of nature. Chemistry abounds in such disclosures, and nowhere more evidently than in the subjects which have been hastily sketched in these papers. But, important as has been the recent progress of organic chemistry, it would seem only to have carried us to the verge of greater discoveries, which must soon reward the labours of the philosophical experimentalist, and that the extraordinary power of electricity will appear among the recondite agents which are concerned in the phenomena of vitality.

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[*] The *contamination*, as it is usually called, of the atmosphere, by the population of London, which considerably exceeds a million persons, must, in reference to the above calculation, be enormous; for the carbonic acid produced by respiration is only a part of that which is poured into the air; *combustion* of coal, gas, tallow, oil, wood, &c., is another prolific source of the same gaseous forms of carbon.

[†] Carbonic acid is considerably heavier than atmospheric air, when both are of the *same temperature*; but as the carbonic acid, *when thrown out of our lungs*, is much warmer than the surrounding atmosphere, it is rendered proportionately bulkier and lighter, and therefore ascends. But were it even not thus disposed of, the tendency of gaseous bodies to mix, or, in the language of Mr. Dalton, to act as *vacua* to each other, would, from the way in which the carbonic acid is thrown from the lungs into the air, immediately diffuse itself. Other causes, illustrated by Professor Graham's experiments on gaseous exosmose and endosmose, are also probably connected with the uniform mixture of the gaseous components of air.

A BRIEF SKETCH OF ENGLISH SCIENTIFIC LITERATURE,

FROM THE INVENTION OF PRINTING TO THE END OF THE SIXTEENTH CENTURY.

[Concluded from Vol. III., p. 445.]

In the former portion of this article nothing has been said of the numerous unpublished scientific manuscripts, of the fifteenth and sixteenth centuries, which are in the various libraries of Great Britain. To mention all would occupy a little volume, and therefore those few only shall be noticed which have fallen under my own observation. Afterwards I shall proceed to describe the published works therein omitted.

John Killingworth wrote a treatise entitled *Canones super Tabulas*, the manuscript of which is in the Bodleian Library: from fol. 28 it appears that he died at Oxford in the year 1444. John Rastell composed his *Canones Astrologici* about 1540, and Edmund Arrowsmith, in 1490, wrote a *Commentary on the Physics of Aristotle*. About the same time Thomas Kent composed *Astronomical Tables*, and Richard Monke, in 1434, wrote a *Calendar*, and a treatise, entitled *Equations of the Planets, and length of the Year*. William Wyrcestre, or Botoner, who died about 1460, wrote a *Canon of Fixed Stars* and a *Treatise on Astrology*.

John Bulkeley wrote a treatise on the *Quadrature of the Circle;* the manuscript, which is apparently prepared for publication, is in the library of Sion College; the dedication is dated 1591, "Ex aulula Mona pridii Calend. Martii." This is probably the earliest English treatise on that celebrated problem, and the attempt, though of course a failure, is ingenious. Francis Mason, fellow of Merton College, Oxford, wrote his *Notes of Astronomy* the same year; the manuscript occurs in the Harleian collection (No. 6494). John Dee composed many works which still remain unpublished, and he enumerates them in his *Letter Apologeticall;* five are in the Cottonian collection—on perspective, mensuration, mechanics, the parabola, and a tract *de Speculis comburentibus*.

Numerous early manuscripts on arithmetic, for the most part anonymous, exist in the various public libraries of England; one thing may be said generally respecting them, that they are perfectly free from all the extraneous matter which was often introduced into the foreign works on the same subject; the commencement of a treatise on *Algorism* is here added, from an old manuscript in my possession, written about the middle of the fifteenth century, in order to give an idea of the style of the scientific works of that period:—

"To alle suche even nombrys as ten, twenty, yritty, an hundrid, an yousand, and suche oyer ye most have cifrys. But he schal vnderstonde yat a cifre tokeney noyinge but he makiy oyer ye more significatyf yat comiy after hym. Also ye schal vnderstonde yat in nombrys composyt, and in alle oyer nombrys yat ben of diverse figurys ye schal begynne in ye riyt syde and so rekene backwarde, and so ye schal wryte as yus 1000. Ye cifre in ye riyt syde was first wryte and yit he tokenay noyinge no ye secunde no ye yridde, but yei maken yat figure of 1 ye more significatyf yat comiy after hem."

John Shirwood wrote a treatise *De Ludo Arithmomachiæ*, which was published at Rome in a small quarto volume, with neither name of printer, nor place, nor date, but the address at the end concludes thus: "Romæ, ipsis Kalendis Aprilibus Anno Domini 1482, &c." It was written for the amusement of Nevil, Archbishop of York, by whom he had long been appointed Archdeacon of Richmond. The date of the address, and the time of printing, are probably very nearly coeval, for in the following year (1483) Shirwood was made Bishop of Durham, and therefore this must have been printed previously, or he would have been so designated. A table explanatory of this Ludus Arithmomachiæ follows the eighth leaf. The manuscript, from which, perhaps, the work was printed, is in the Bodleian Library.

The numerous treatises by Anthony Ascham, purporting to be on astronomy, abound in absurdities, and appear designed for the purpose of attracting the attention of the credulous. Frederic van Brunswick translated the *Facies Cœli* of Montulmo (8vo. 1554,) putting forth predictions for two years. Record treats of astronomy in his *Pathway* and *Castle of Knowledge*. William Cunningham, in 1559, published a treatise on cosmography, which was the first on that subject; a very curious wooden design of the sciences ornaments the title-page, and in a few copies is a print of the author's head in his twenty-eighth year. Abraham Fleming, in 1557, translated the treatise of Frederic Nause on *Blazing Starres* or comets; and, in the same year, a work of John Vowell appeared on the comet which was then visible, principally relating to its pretended disastrous effects: another tract on the same comet appeared the following year. Robert Green, in 1585, put forth his *Planetomachia*, a treatise on the seven planets; Robert Tanner, two years afterwards, published his *Mirrour for Mathematickes*, containing a description of the astrolabe; and Humphrey Baker, the same year, translated a treatise on almanacs and astrology. Emery Molineux wrote on the globes in 1592, and the same year Thomas Dawson printed an anonymous tract on the same subject.

William Fulke, in 1563, published his *Goodlye Gallerie*, a small treatise on the causes of meteors, &c. D. P. wrote *Certaine Breife Rules of Geographie*, with a view of teaching the use of maps and charts, published in 1573. Abraham Fleming, in 1580, translated the treatise on *Earthquakes* by Frederic Nause. In 1581 Robert Norman set forth a curious treatise under the following title:—

> *The Newe Attractive, containyng a short discourse of the Magnes or Lodestone, and, amongest other his vertues, of a newe discovered secret and subtill propertie, concernyng the Declyning of the Needle touched there with, under the plaine of the Horizon. Whereunto are annexed certaine necessarie Rules for the Art of Navigation.* Imprinted at London, by Jhon Kyngston, 1581. 4to., 39 leaves. Reprinted 1583 and 1596.

The dip or inclination of the needle, when at liberty to play vertically, to a point beneath the horizon, was first published in this work; it appears that he had discovered it a few years previously, and he gives the "meanes by which it was founde" in his third chapter. He also treats of the declination of the needle, and other matters relative to navigation. The well-known work of Taisner* on the loadstone, and perpetual motion by means of it, was translated by Richard Eden in 1587. In 1593 the "Art of Dialling," by Thomas Fale appeared, and in the following year was published an anonymous treatise on navigation, written very clearly for the use of tyros, as also the astronomical tables of George Hartgill, and Platte's "Jewel House of Art and Nature," a work on husbandry, minerals, chemistry, &c.

To the *Newe Attractive* of Robert Norman was annexed *A Discours of the Variation of the Compass, or Magneticall Needle*, by William Borough, giving a description of a new instrument for the variation. The former also translated from the Dutch the *Safeguard of Saylors*, containing notes on the tides, currents, &c., and cautions to sailors entering the different English and Dutch ports, published first at London in 1584, and reprinted in 1600 and 1647.

In 1582 George Letton printed a work by Edward Worsop, entitled *A Discoverie of sundrie errors committed by Lande-Meaters ignorant of Arithmeticke and Geometrie.* Robert Agas wrote a small treatise, which was published in 1596, called *A preparative to platting of Landes and Tenements for surveigh;* and there was a *Boke of Surveying*, published about 1530, but it relates only to agriculture.

Thomas Hyll published an *Almanac* for the year 1573, which, in the opinion of Mr. Douce, may be considered as the earliest regular publication of that kind that appeared in England. Two posthumous works by him were published some years afterwards; the *Schoole of Skil*, (London, 4to., 1599,) containing a few common-place matters relative to astronomy, and *The Arte of Vulgar Arithmetick* (4to. 1600.)

Thomas Hood, who styles himself "mathematical lecturer in London," and a "Doctor in Physicke" appears to have been a good practical mathematician for the time in which he flourished. A speech made by him at a city dinner was published in 1588; he edited the reprint of Bourne's *Regiment of the Sea* in 1592, and added thereunto *The Mariner's guide, set forth in form of a dialogue, wherein the use of the plaine Sea-card is planely delivered.* In 1590 he published a treatise on the projection of the sphere, which certainly does not reflect any very great credit on its author. His *Making and Use of the Sector* (4to., 56 leaves,) was written in 1598, and soon after printed; his translation of Ustitius on arithmetic has already been mentioned.

John Blagrave, besides the treatise already noticed, wrote several others, of which the one most deserving notice is his *Mathematical Jewel*, which was printed in 1585, and contains a description of a new mathematical instrument of that name, and some propositions on spherical geometry. His *Baculum Familiare Catholicon, sive Generale. A booke of the making and use of a Staffe, newely invented by the Author*, printed in 1590; and his *Art of Dialling*, dedicated to Sir Thomas Parry, and printed in 1609 (4to.) are in the Library of the Royal Society. He also edited a work of Dariot on the Astrolabe, published in 1596.

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* It was the opinion of this author, Peter Peregrinus, Cardan, and others, that it is possible to contrive several pieces of steel and a loadstone, that by their continual attraction and repulsion, they may cause the perpetual revolution of a wheel. —See *Peregrinus de Rota Perpetui Motus*, par. 2, c. 3; *Cardan. de Variet. Rerum*, l. 9, c. 48; and *Gilbert de Magnete*, l. 2, c. 35.

Cyprian Lucar, in 1588, published a translation of the work of Tartalea on gunnery. Two years afterwards another treatise appeared by the same author:—

> *A Treatise named Lucarsolace devided into fower bookes, which in part are collected out of diverse authors in diverse languages, and in part devised by Cyprian Lucar, Gentleman.* Imprinted at London, by Richard Field. 1590. 4to. 87 leaves.

A work on practical geometry, agriculture, &c. At page 157, he gives a description of a rude fire-engine, which he designates by the name of a squirt, and opposite to that page is a rough sketch of the squirt in question operating on a house enveloped in flames. The engine consists of a large hollow cone, moveable on a wooden frame, and open at the vertex, into which is inserted a long pipe for the passage of the water, which being continually thrown into the cone through a tunnel near the vertex, is ejected by a piston at the other extremity, on a principle precisely similar to that of the squirt.

But the most singularly interesting and curious volume that appeared in this century was a treatise on algebra by Robert Recorde, published in 1557, under the following quaint and unassuming title:—

> *The Whetstone of Witte, which is the seconde parte of Arithmetike; containyng thextraction of Roots, the Cossike Practice, with the Rule of Equation: and the Woorkes of Surde Nombers.*
>
> Though many stones do beare greate price,
> The whetstone is for exercise
> As neadefull, and in woorke as straunge:
> Dulle thinges and harde it will so chaunge,
> And make them sharpe, to right good use:
> All artesmen knowe there can not chuse,
> But use his helpe: yet as men see,
> Noe sharpeness semeth in it to bee.
>
> The *grounde of artes* did bred this stone:
> His vse is greate, and moare than one.
> Here if you list your wittes to whette,
> Moche sharpnesse thereby shall you gette.
> Dulle wittes hereby doe greatly mende,
> Sharpe wittes are fined to their fulle ende,
> Now prove, and praise, as you doe finde,
> And to yourself be not vnkinde.
>
> *These Bookes are to bee solde, at the Weste doore of Poules, by Jhon Kyngston.*

This is not only the first work on Algebra in the English language, but the first of its kind published in England. The principal thing new by this author is the sign of equality, and the extraction of the roots of compound algebraic quantities; but as this work is well known, and descriptions of it have been given by Hutton, Bonnycastle, and others, it is unnecessary to add more.

The great barrier that the Copernican system, in its progress, had to overcome, was the universal acquiescence in the doctrines of Aristotle; for his name reigned paramount in every department of learning: and it is a curious fact that, so late as the seventeenth century, in some of the universities of Europe, the professors were required to declare, upon oath, their belief that those doctrines were infallible, and promise, in their public lectures, to follow Aristotle as their only guide. For this reason Digges, in his arguments against the Ptolemaic system, finds it expedient to introduce Aristotle as a seeming authority.

"If, therefore, the earth be situate immoveable in the center of the world, why finde we not theoricks upon that ground to produce effects as true and certaine as those of Copernicus? Why cast wee not away those *circles æquantes* and motions irregular? seeing our own philosopher Aristotle himselfe the light of our universities hath taught vs: *Simplicis corporis simplicem oportet esse motum.* But if contrarie, it bee found impossible (the earth's stabilitie being graunted,) but that we must necessarily fall into these absurdities, and cannot by any meane avoyde them: why shall wee so much dote in the apparence of our sences, which many waies may be abused, and not suffer ourselves to be directed by the rule of reason, which the great God hath given us as a lampe to lighten the darkness of our understanding, and the perfect guide to leade us to the golden braunch of veritie amidde the forrest of errors*."

The same writer, also, at the end of his *Stratioticos*, in a list of "bookes begon by the author hereafter to be published," mentions one entitled "Commentaries upon the Revolutions of Copernicus," but it never appeared. From a passage in "Record's Castle of Knowledge," (1556) quoted in the "Companion to the British Almanac," it appears that he was a Copernican, but afraid to avow his belief in it openly.

The following works have no dates, and as exactness is not easy to be obtained in such matters, I shall not even hazard a guess as to the precise period of their appearance:—

Charles Turnbull, his perfect and easy Treatise of the Cælestiall Globe. 8vo. Simon Waterson.

Dialogues of the Sunne and Moone. 8vo. Robert Wyer.

A Treatise of Measures and Weights. 12mo. Nicolas Hill.

Anthony Ashley, about 1588, published a treatise on navigation, entitled the *Mariner's Mirrour;* John Dee wrote a *Triple Almanack* for 1591, and the same year Francis Cooke translated a treatise of George Hemischius on geometry, astronomy, and geography.

It must not be supposed that I have attempted to give a history of English science during the above-mentioned period, for the mention of

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* Addition to the *Prognostication Everlasting*, by T. Digges. Besides the two reprints before-mentioned, there are three others, 1585, 1594, and 1596.

A TABLE *of the Action of Reagents on Solutions of some of the Metallic Oxides and their Salts.*

REAGENTS.	SILVER.	MERCURY.		GOLD.	PLATINUM.	TIN.		ANTIMONY.	CHROMIUM.
		Protoxide.	Peroxide.			Protoxide.	Peroxide.	Protoxide.	
Pure or Caustic Potassa	1 light brown	1 black	1 yellow	1 black	1 yellow	1 white	1 white	1 white	1 green
Pure or Caustic Ammonia	2 brown	1 black	2 white	2 yellow	2 yellow	2 white	1 white	1 white	2 grayish-blue
Carbonate of Potassa	3 white	2 dirty yellow	3 red brown	——	3 yellow	2 white	2 white	1 white	3 light green
Bicarbonate of Potassa	3 white	2 white	3 red brown	——	3 yellow	2 white	white	1 white	3 light green
Carbonate of Ammonia	3 white	3 gray or black	white	yellow	3 yellow	2 white	white	1 white	3 light green
Phosphate of Soda	4 yellow	white	4 white	——	——	white	white	1 white	light green
Oxalic Acid	5 white	white	5 white	3 metallic gold	——	white	white	1 white	——
Prussiate of Potassa	6 white	4 white and gelatinous	6 white	4 ——	yellow	3 white and gelatinous	3 a jelly	2 white	——
Red Prussiate of Potassa	7 red brown	5 red brown.	yellow	——	yellow	4 white	4 ——	3 ——	——
Hydrosulphuret of Ammonia	8 black	6 black	7 black	5 dark brown	4 black	5 brown	5 yellow	4 red	4 greenish
Liquid Sulphuretted Hydrogen	9 black	7 black	8 black	6 black	5 brown	6 dark brown	6 yellow	5 red	5 ——
Sulphuretted Hydrogen Gas	9 black	7 black	8 black	6 black	5 brown	6 dark brown	6 yellow	6 red	5 ——
Sulphuric Acid, and Soluble Sulphates	——	——	——	——	——	——	——	——	6 white
Muriatic Acid, and Chlorides	10 white	8 white	white	——	——	——	——	——	——
Iodide of Potassium	11 white	9 greenish-yellow	9 red	7 yellow green	6 brown	7 yellow white	——	——	6 greenish-white
Chromate of Potassa	12 red brown	red	10 yellow red	——	——	——	——	——	7 yellow
Protochloride of Tin	white	white	white	8 purple	7 ——	——	——	——	——
Protosulphate of Iron	13 white metal. silver	——	——	9 brown metallic gold	——	——	——	——	——
Water	——	——	——	——	——	——	——	white	——
Precipitated in the metallic state by Metals	zinc, copper, mercury	zinc, copper	zinc, copper	zinc, copper, bismuth, iron, mer.	zinc	zinc	zinc	zinc, iron	——
Before the blowpipe colour fluxes	milky	——	——	——	——	white	white	——	green

many works prominent in importance has been purposely omitted, to avoid repetition, and full descriptions of none have been given; for besides the degree of space required, their contents are not in general of sufficient importance to merit any lengthy notice: a sketch is all that has been aimed at, and my only object was to supply the names and general contents of works omitted by historians of mathematical literature. The article in the "Companion to the British Almanac" contains an ample description of all Record's works, as well as most of the writings of Dee and Digges. We are indebted for all the other little information that we possess to incidental notices by authors not writing expressly upon the subject. J. L.

A. P. July 12*th*, 1837.

A POPULAR COURSE OF GEOLOGY.

X.

CHEMICAL CHARACTERS OF MINERALS, *concluded*.—TESTS FOR METALS; TESTS FOR ACIDS.

SILVER = 110. Specific gravity, 10·51.

SILVER is the most white of all the metals, and is susceptible of a lustre inferior only to that of polished steel. It possesses considerable malleability and ductility, yielding in the two latter qualities only to gold. It is soft and sectile when pure, and rather easily fused. Silver occurs native, and in combination with sulphur, gold, antimony, copper, and arsenic. Moisture and exposure to air have no oxidizing effect on pure silver; neither is it oxidized by fusion in open vessels. A film of oxide, it is true, forms on the surface of melted silver exposed to a stream of air or oxygen gas; but the oxygen is given out again as the silver cools.

Nitric acid is the proper solvent for silver; sulphuric acid only affects it when assisted by heat. No other acids have any action on this metal. A solution of silver forms the basis of permanent ink, and the salt in its fused state is known by the name of *lunar caustic*. There is but one oxide of silver, which is of a brown colour, insoluble in water, and is reduced to metallic silver at a red heat. It is soluble in nitric acid, and in some other acids. Its solutions behave towards reagents as follows:—

1. *Potassa* produces a light brown precipitate insoluble in an excess of the precipitant, but soluble on the addition of ammonia.

2. *Ammonia*, in neutral solutions, in small quantities, a brown precipitate, dissolving with great facility on the addition of a little more ammonia.

No precipitate is produced in a solution of silver containing free acid, by saturation with ammonia.

3. *Carbonate and bicarbonate of Potassa, and carbonate of Ammonia.*—White precipitates, soluble in ammonia.

4. *Phosphate of Soda.*—In neutral solutions, a yellow precipitate, soluble in ammonia.

A Table *of the Action of Reagents on Solutions of some of the Metallic Oxides and their Salts.*

REAGENTS.	SILVER.	MERCURY.		GOLD.	PLATINUM.	TIN.		ANTIMONY.	CHROMIUM.
		Protoxide.	Peroxide.			Protoxide.	Peroxide.	Protoxide.	
Pure or Caustic Potassa	1 light brown	1 black	1 yellow	1 black	1 yellow	1 white	1 white	1 white	1 green
Pure or Caustic Ammonia	2 brown	1 black	2 white	2 yellow	2 yellow	2 white	1 white	1 white	2 grayish-blue
Carbonate of Potassa	3 white	2 dirty yellow	3 red brown	—	3 yellow	2 white	2 white	1 white	3 light green
Bicarbonate of Potassa	3 white	2 white	3 red brown	—	3 yellow	2 white	white	1 white	3 light green
Carbonate of Ammonia	3 white	3 gray or black	white	yellow	3 yellow	2 white	white	1 white	3 light green
Phosphate of Soda	4 yellow	white	4 white	—	—	white	white	1 white	light green
Oxalic Acid	5 white	white	5 white	3 metallic gold	—	white	white	1 white	—
Prussiate of Potassa	6 white	4 white and gelatinous	6 white	4 —	yellow	3 white and gelatinous	3 a jelly	2 white	—
Red Prussiate of Potassa	7 red brown	5 red brown	yellow	—	yellow	4 white	4 —	3 —	—
Hydrosulphuret of Ammonia	8 black	6 black	7 black	5 dark brown	4 black	5 brown	5 yellow	4 red	4 greenish
Liquid Sulphuretted Hydrogen	9 black	7 black	8 black	6 black	5 brown	6 dark brown	6 yellow	5 red	5 —
Sulphuretted Hydrogen Gas	9 black	7 black	8 black	6 black	5 brown	6 dark brown	6 yellow	6 red	5 —
Sulphuric Acid, and Soluble Sulphates	—	—	—	—	—	—	—	—	6 white
Muriatic Acid, and Chlorides	10 white	8 white	white	—	—	—	—	—	—
Iodide of Potassium	11 white	9 greenish-yellow	9 red	7 yellow green	6 brown	7 yellow white	—	—	6 greenish-white
Chromate of Potassa	12 red brown	red	10 yellow red	—	—	—	—	—	7 yellow
Protochloride of Tin	white	white	white	8 purple	7 —	—	—	—	—
Protosulphate of Iron	13 white metal. silver	—	—	9 brown metallic gold	—	—	—	—	—
Water	—	—	—	—	—	—	—	white	—
Precipitated in the metallic state by Metals	zinc, copper, mercury	zinc, copper	zinc, copper	zinc, copper, bismuth, iron, mer.	zinc	zinc	zinc	zinc, iron	—
Before the blowpipe colour fluxes	milky	—	—	—	—	white	white	—	green

5. *Oxalic Acid.*—In neutral solutions, a white precipitate, soluble in ammonia.

6. *Prussiate of Potassa.*—A white precipitate.

7. *Red Prussiate of Potassa.*—A reddish-brown precipitate, much resembling that thrown down by ammonia from solutions of peroxide of iron.

8. *Hydrosulphuret of Ammonia.*—A black precipitate, insoluble in an excess of the precipitant.

9. *Liquid sulphuretted Hydrogen, and sulphuretted Hydrogen Gas.*—A black precipitate, both in neutral and acid solutions.

10. *Muriatic Acid, and Solutions of the Chlorides.*—Even in very dilute solutions, a white precipitate, soluble in ammonia, insoluble in diluted acids, and changing to a gray or violet colour by exposure to the light of the sun.

In solutions containing only a small quantity of silver the precipitate subsides slowly, and the solution is opalescent; in solutions containing a larger quantity of silver the precipitate is flocculent.

11. *Iodide of Potassium.*—A white precipitate, inclining to yellow, soluble in an excess of the precipitant, but sparingly soluble in ammonia.

12. *Chromate of Potassa.*—A dark reddish-brown precipitate, soluble in diluted nitric acid and in ammonia.

13. *Protosulphate of Iron.*—A white precipitate, which is metallic silver.

Metallic Zinc, Copper, and Mercury, precipitate silver in the metallic state.

Silver is best detected in solution by means of muriatic acid.

Before the blowpipe, salts of silver are easily reduced to the metallic state by fusion with soda on charcoal. With *borax,* oxide of silver partly reduces, partly dissolves. The glass formed by the exterior flame becomes milky on cooling; that formed by the interior flame is of a grayish colour, from disseminated particles of reduced metal.

With *microcosmic salt,* it dissolves quickly and copiously, producing in the exterior flame an opalescent glass, yellow by day-light, red by candle-light. The presence of copper is indicated by a green colour, and that of gold by a ruby colour. A piece of metallic copper produces a precipitation of metallic silver from the fused globule, which becomes of a pellucid green.

MERCURY = 200. Specific gravity, 13·545 fluid, 15·612 solid.

MERCURY is of a white colour, with a strong metallic lustre, and is distinguished from other metals by being fluid at ordinary temperatures. At about 40° below zero it becomes solid, and is then malleable and sectile. It is volatile in the fire, and condenses again on cold surfaces into metallic globules. Mercury, when quite pure, is not oxidized by air and moisture; but an amalgam of mercury with other metals oxidizes rapidly, and a film is formed on the surface. When mercury, in the state of vapour, is exposed to a stream of air or oxygen, it slowly absorbs oxygen, and is converted into the peroxide.

The ores of mercury are not numerous. It occurs in the metallic state, but is more commonly found as the sulphuret, which goes in commerce by the name of *cinnabar*. The nitric and sulphuric acids are the only acids that have any action on mercury; the former in the cold, the latter only on the application of heat. There are two oxides of mercury, both of which form salts with acids.

THE PROTOXIDE.

THIS is a black powder, insoluble in water. It is difficult to be procured in a pure state, from its tendency to acquire a further proportion of oxygen, and to resolve itself into the peroxide and metallic mercury. It gives with—

1. *Potassa and Ammonia* a black precipitate, insoluble in an excess of the precipitant.

2. *Carbonate and Bicarbonate of Potassa.*—The former a dirty yellow, the latter a white precipitate rendered black by boiling.

3. *Carbonate of Ammonia.*—A precipitate of protocarbonate, which is gray or black as the protoxide of mercury is present in small or large quantities.

4. *Prussiate of Potassa.*—A white gelatinous precipitate.

5. *Red Prussiate of Potassa.*—A reddish-brown precipitate, which after a time turns white.

6. *Hydrosulphuret of Ammonia.*—An immediate black precipitate of protosulphuret of mercury, insoluble in an excess of the precipitant, and also in ammonia.

7. *Liquid sulphuretted Hydrogen, and sulphuretted Hydrogen Gas.*—An immediate black precipitate, both in neutral and acid solutions.

8. *Muriatic Acid, and Solutions of the Chlorides.*—A white precipitate, (calomel,) which is insoluble in acids, and is blackened by ammonia.

9. *Iodide of Potassium.*—A greenish-yellow precipitate, which a further quantity of the reagent renders black, and a still larger quantity dissolves.

Metallic Zinc precipitates mercury in the metallic state as a gray coating, which is an amalgam of zinc and mercury. Bright copper, after remaining some time in a solution of salts of mercury, is covered with a silvery stain, which disappears at a red heat.

The most characteristic test for mercury is muriatic acid. The conversion of the white colour of the precipitate formed by that reagent to black, by ammonia, distinguishes the mercurial precipitate from that formed by muriatic acid in solutions of silver. *Before the blowpipe*, mercury, being volatile, has no effect on the fluxes. The compounds of mercury are therefore best examined by heating them in a small matrass or glass tube, when the mercury sublimes, and collects on the cool part of the glass, as a gray powder, which consists of metallic globules.

PEROXIDE OF MERCURY.

THIS oxide of mercury is crystalline, and of a brick-red colour, and is sparingly soluble in water, forming a solution which has an acrid metallic taste, and changes to green the blue infusion of violets. When heated to redness, or exposed to the long-continued action of light, it is decomposed, and converted into metallic mercury and oxygen. Peroxide of mercury is easily soluble in acids. Its solutions exhibit the following appearances with reagents:—

1. *Potassa.*—A yellow precipitate, insoluble in an excess of the precipitants. If a very small quantity of the reagent be used, the precipitate will be reddish-brown. If the solution contain muriate of ammonia, or much free acid, the precipitate will be white.

2. *Ammonia.*—A white precipitate, not soluble in an excess of the precipitant.

3. *Carbonate and Bicarbonate of Potassa.*—A reddish-brown precipitate, insoluble in an excess of the precipitants. The presence of muriate of ammonia in the solution causes the precipitate to be white.

4. *Phosphate of Soda.*—A white precipitate in solutions of pernitrate or persulphate, but in solutions of perchloride only a slight troubling.

5. *Oxalic Acid.*—A white precipitate in solutions of the pernitrate and persulphate; none in solutions of the perchloride.

6. *Prussiate of Potassa.*—A white precipitate, which changes to blue.

7. *Hydrosulphuret of Ammonia.*—A small quantity produces a black precipitate, where it comes in contact with the liquid. This becomes quite white when the mixture is shaken. If more of the hydrosulphuret be gradually added, the resulting precipitate will be a mixture of black and white, and an excess of it renders the precipitate quite black. The precipitate is insoluble in ammonia, but dissolves completely in a solution of potassa.

8. *Liquid Sulphuretted Hydrogen, and Sulphuretted Hydrogen Gas.*—The phenomena are the same as with the last reagent.

9. *Iodide of Potassium.*—A cinnabar-red precipitate, soluble in an excess of the reagent, soluble also in muriatic acid.

10. *Chromate of Potassa.*—A yellowish-red precipitate, unless the solution be too dilute.

Metallic Zinc and Copper produce the same effects in solutions of peroxides of mercury as in those of the protoxide, and before the blowpipe the two oxides and their compounds behave in the same manner.

The persalts of mercury are characterized by their behaviour with hydrosulphuret of ammonia, or better, by their behaviour with sulphuretted hydrogen gas.

GOLD = 200. Specific gravity 19·3.

GOLD is distinguished from all other simple metallic bodies by its well-known yellow colour. It has never been found except in the metallic state, sometimes disseminated through rocks, but more frequently in alluvial deposits. It is susceptible of a high lustre by polishing, though inferior to that of steel and silver. Pure gold is very soft and flexible; it is the most malleable and ductile of metals, though inferior to several in tenacity. Gold is not oxidized by exposure to air and moisture, nor by being kept in a state of fusion in contact with the atmosphere. The result of its combustion, by means of the oxy-hydrogen blowpipe or electricity, is a purple powder, supposed to be an oxide. None of the pure acids have any effect on gold, even when heated; its only solvents are chlorine and a mixture of nitric and muriatic acid, and it appears that chlorine is, in both cases, the solvent, since nitro-muriatic acid has no effect on gold when chlorine is not formed.

Some chemists are of opinion, that there are three oxides of gold, but the only well-known oxide is that which is supposed to exist in the solution of the chloride of this metal, from which it is obtained by precipitation with potassa.

Reagents produce the following effects on a solution of chloride of gold.

1. *Pure Potassa.*—No precipitate at first, but, after a time, the solution acquires a greenish colour, and deposits a trifling black precipitate.

2. *Ammonia.*—In solutions of chloride, a yellow precipitate, which is fulminating gold, a highly-detonating and dangerous compound.

3. *Oxalic Acid.*—The colour of a solution of chloride of gold is first changed by this reagent to a dark greenish-black; after some time, a brown powder subsides, which is metallic gold.

Precipitation is effected more rapidly when the mixture is heated.

4. *Prussiate of Potassa* communicates to solutions of gold an emerald green colour.

The *Red Prussiate* occasions no change.

5. *Hydrosulphuret of Ammonia.*—A dark-brown precipitate, which redissolves in an excess of the precipitant.

6. *Liquid Sulphuretted Hydrogen and Sulphuretted Hydrogen Gas.*—A black precipitate, both in neutral and acid solutions.

7. *Iodide of Potassium.*—In diluted solutions of chloride of gold, a blue colour, afterwards a yellowish-green precipitate subsides, leaving free iodine dissolved in the solution.

8. *Protochloride of Tin.*—In concentrated solutions of gold, a dark reddish-purple precipitate, insoluble in free muriatic acid. In dilute solutions, the purple colour is merely communicated to the solution.

9. *Protosulphate of Iron.*—In diluted solutions of chloride of gold, a blue colouring, and, after a time, a brown-coloured precipitate of metallic gold.

Metallic Zinc precipitates gold from its solutions, as a brown bulky coating.

The tests by which gold is best detected in solution are protosulphate of iron, oxalic acid, and protochloride of tin.

Fluxes have no action on gold; they merely, by the colour communicated to them, indicate the metals with which it is alloyed.

PLATINUM = 96. Specific gravity 21·5.

PLATINUM is found in the metallic state combined with copper, iron, lead, gold, silver, palladium, rhodium, osmium, and iridium. The chief supplies of it are derived from Brazil, Peru, and the Uralian mountains. It generally occurs in round or flattened grains, of a white colour and metallic lustre, mixed with alluvial sand and gravel. In the Uralian mountains, it has likewise been found in veins associated with gold, and these mountains contain rich mines of these two metals. It has also been found in veins in North America.

Pure platinum is white like silver, but possesses less lustre. It is the heaviest of all known metals. In malleability, it is rather inferior to gold, but its tenacity is such, that it may be drawn out into wires not more than the 2000th part of an inch thick. It may be welded like iron, and is a less perfect conductor of caloric than most other metals. It is not changed by the action of air and moisture, nor is it oxidized or fused by long exposure to a white heat; a wire of it heated by means of galvanism or the oxy-hydrogen blowpipe, fuses and burns with scintillation. It is not attacked by any acids, and its only solvents are chlorine and nitro-muriatic acid, which act upon it with more difficulty than upon gold. Its infusibility and power of resisting the attacks of acids render it a metal of great value for the formation of crucibles and other chemical apparatus; and the discovery of this metal, and of its applicability to these purposes, has added much to the accuracy of chemical analysis. In a solution of chloride of platinum, the following precipitates are produced by reagents.

1. *Pure Potassa.*—The yellow crystalline precipitate which we have before mentioned, when speaking of chloride of platinum as a test for potassa. It is not soluble in acids, but dissolves when heated in an excess of potassa; and is not again precipitated when the liquor cools. Supersaturation with muriatic acid causes the re-appearance of the precipitate.

2. *Ammonia.*—A yellow precipitate, similar to that produced by potassa, insoluble in acids, soluble when heated in an excess of ammonia. On supersaturating this solution with muriatic acid, a white precipitate is produced.

3. *Carbonate aad Bicarbonate of Potassa, and Carbonate of Ammonia.*—A yellow precipitate, which does not dissolve when heated in an excess of these precipitants.

Prussiate and Red Prussiate of Potassa.—A yellow precipitate of chloride of platinum and potassa; the solution at the same time acquiring a darker colour.

Hydrosulphuret of Ammonia.—The colour of the solution becomes a deep reddish-brown, and a brownish-black precipitate is produced, soluble in a considerable excess of the precipitant.

5. *Liquid Sulphuretted Hydrogen, and Sulphuretted Hydrogen Gas.*—In acid and neutral solutions, at first only a change of colour, but after some time, a brown precipitate, which becomes black.

6. *Iodide of Potassium.*—The solution acquires a deep reddish-brown colour, and, after a time, a brown precipitate takes place, of a lighter colour than the solution. By heating the solution, a metallic coating is deposited on the glass.

7. *Protochloride of Tin.*—A deep reddish-brown colour is communicated to the solution, but no precipitate is produced.

Metallic Zinc precipitates platinum as a black metallic powder.

Before the blowpipe, compounds of platinum are reduced, but communicate no colour to the flux.

TIN = 58. Specific gravity 7 to 9.

THE ore from which tin is procured is an oxide, which is reduced by means of heat and charcoal. In the metallic state, tin is white, with a lustre resembling that of silver. It soon loses its brilliancy, but is not oxidized by the combined action of heat and moisture. It has a considerable degree of malleability, but is less ductile than some other metals. It is soft and inelastic, and emits a creaking sound when bent. There are two oxides of tin.

When tin is kept in a state of fusion, exposed to the air, a gray powder is formed on its surface, which is the protoxide. Both the oxides form salts with acids, and also combine with alkalies.

Protoxide of tin has a powerful affinity for oxygen, and when heated to whiteness in contact with the air, it burns with a white flame, and is converted into the peroxide. Its salts not only absorb oxygen from the air, but have a powerful deoxidizing effect on other substances, converting peroxides of iron and copper into protoxides, precipitating silver, mercury, and platinum, in the metallic state, and precipitating a purple powder from a solution of gold.

PROTOXIDE OF TIN.

1. *Potassa.*—A white precipitate, soluble in an excess of the precipitant.

2. *Ammonia*, *Carbonate and Bicarbonate of Potassa*, and *Carbonate of Ammonia*, all give white precipitates, insoluble in an excess of the precipitants.

3. *Prussiate of Potassa.*—A white gelatinous precipitate.

4. *Red Prussiate of Potassa.*—A white precipitate, soluble in muriatic acid.

5. *Hydrosulphuret of Ammonia.*—A brown precipitate, soluble in a great excess of the precipitant. Muriatic acid added in excess to this sulphuretted solution, causes a yellow precipitate.

6. *Liquid Sulphuretted Hydrogen, and Sulphuretted Hydrogen Gas.*—A dark-brown precipitate, both in neutral and acid solutions.

7. *Iodide of Potassium.*—A white flocculent precipitate, inclining to yellow, and, after a time, becoming cinnabar-red. It dissolves in a great excess of the precipitant.

Metallic Zinc precipitates tin in the metallic state, from solutions of its salts, as small white spangles.

Before the blowpipe, the protosalts of tin are easily reduced on charcoal with soda, in the inner flame. The bead may be known to be tin by its capability of being flattened by the hammer, and by its depriving of its green colour the bead formed by fusion of microscosmic salt with copper, rendering it opaque and brownish-red. Solutions of protoxide of tin are recognised by their producing a purple precipitate with solutions of gold.

PEROXIDE OF TIN.

WHEN protoxide of tin is heated to whiteness, it takes fire, and burns with a white flame, and is converted into the peroxide. The peroxide is also procured by the action of nitric acid slightly diluted upon metallic tin; nitrous acid and deutoxide of nitrogen are evolved, and a white powder subsides, which is the hydrate of the peroxide. This, on being heated to redness, gives off water, leaving the pure oxide, which is of a white, or straw yellow colour, and has but a feeble affinity for acids. The native protoxide of tin is dark, owing to the presence of foreign matter. Peroxide of tin, after ignition, is completely insoluble in acids, and can only be brought into a state of solution by fusion with a carbonated alkali.

Reagents produce the following effects in solutions of peroxide of tin:—

1. *Potassa and Ammonia.*—White precipitates, soluble in an excess of the precipitants.

2. *Carbonate of Potassa.*—A white precipitate, with disengagement of carbonic acid gas. The precipitate dissolves in an excess of the precipitant.

3. *Prussiate of Potassa.*—No immediate precipitate, but, after some time, a white troubling, and after a still longer time, the whole mixture congeals into a stiff jelly, insoluble in muriatic acid.

4. *Red Prussiate of Potassa.*—No precipitate.

5. *Hydrosulphuret of Ammonia.*—In neutral solutions, a yellow precipitate, soluble in an excess of the precipitant.

6. *Liquid Sulphuretted Hydrogen, and Sulphuretted Hydrogen Gas.*—In neutral and acid solutions, no immediate effect, but, after some time, a yellow precipitate subsides. Precipitation is hastened by boiling the solution with liquid sulphuretted hydrogen.

Metallic Zinc separates tin from its solutions, with disengagement of hydrogen gas, as a white gelatinous precipitate, which is the peroxide. Tin is best detected in solution by its behaviour with liquid sulphuretted hydrogen, and with hydrosulphuret of ammonia.

Before the blowpipe, the persalts of tin are reduced to the metallic state with the same facility as the protosalts.

ANTIMONY = 44. Specific gravity 6·7.

THE sulphuret of antimony, from which most of the antimony of commerce is derived, is the most abundant ore of that metal, though it sometimes occurs in the metallic state. Metallic antimony is procured from the sulphuret, by heating it in a covered crucible, with half its weight of iron filings, when the sulphur combines with the iron; or by mixing two-thirds of its weight of cream of tartar, and one-third of nitre, and throwing the mixture, by a little at a time, into a red-hot crucible, when the sulphur is expelled in the form of sulphurous acid. Metallic antimony is of a white colour, inclining to blueish-gray, easily fusible, and crystallizing, when slowly cooled, into octohedrons or dodecahedrons. It is volatile if fused in contact with atmospheric air or gaseous matters, but not if they are excluded. Heated to a white or full red heat in a covered crucible, and then suddenly exposed to the air, it inflames, and burns with a white light.

There has been much discussion among chemists as to the number of oxides of antimony; but it is now generally admitted that there are three, of which the protoxide is the only one that forms regular salts with acids; the deutoxide and peroxide combine with alkalies, and have therefore been called by Berzelius, antimonious and antimoniac acids, and their salts, antimonites and antimoniates.

PROTOXIDE OF ANTIMONY.

PROTOXIDE of antimony, when pure, is white, but acquires a yellow tint by being heated, and at a dull red heat, in close vessels, fuses to a yellow fluid, which becomes grayish, opaque, and crystalline as it cools. Heated under such circumstances as to exclude atmospheric air, it sublimes, and may be condensed again on a cool surface, without undergoing any change. Heated in contact with the air, it gives out white smoke, and is partly converted into antimonious acid. The protoxide is insoluble in nitric, but soluble in muriatic acid; the resulting solution becomes milky on being diluted with water, but may be rendered clear again by the addition of a diluted acid.

1. *Pure Potassa and Ammonia, Carbonate and Bicarbonate of Potassa, Carbonate of Ammonia, Phosphate of Soda,* and *Oxalic Acid,* all produce, in solutions of protoxide of antimony, white precipitates, insoluble in an excess of the precipitants; but those produced by the last two reagents would also be produced by the water contained in them.

2. *Prussiate of Potassa.*—A white precipitate, insoluble in muriatic acid.

3. *Red Prussiate of Potassa.*—No precipitate, but after some time, a slight opacity, which is removed by the addition of muriatic acid.

4. *Hydrosulphuret of Ammonia.*—A red precipitate, completely soluble in an excess of the precipitant.

5. *Liquid Sulphuretted Hydrogen, and Sulphuretted Hydrogen Gas.*—In acid and neutral solutions, an orange-red precipitate. Should the solution of antimony be neutral, its colour is at first only changed by the sulphuretted hydrogen; but by the addition of muriatic acid, or the exposure of the mixture to heat, a precipitate is immediately formed.

Metallic Zinc precipitates antimony in the metallic state from its solutions, as a black powder.

Before the blowpipe, compounds of antimony with soda on charcoal in the inner flame, are reduced. The bead of antimony remains long in a melted state after the discontinuance of the blast, and gives off a thick white smoke. On cooling, it is covered with a net-work of crystals, which are protoxide of antimony. Antimony is best detected in its solutions by sulphuretted hydrogen and hydrosulphuret of ammonia.

Before the blowpipe, with *borax*, the compounds of antimony dissolve largely, forming a glass, yellow while hot, nearly colourless when cold. In the inner flame, partial reduction of the metals renders the glass opaque. With *microcosmic salt* in the external flame, they form a transparent yellow glass, the colour of which disappears as it cools.

ARSENIC = 38. Specific gravity 8·3.

ARSENIC is sometimes found in the metallic state, but it occurs more commonly combined with other metals, particularly cobalt and iron. On roasting these arseniurets in a reverberatory furnace, the arsenic sublimes, and condenses on the roof in thick cakes, which, after being purified by a second sublimation, become the *arsenic*, or *white oxide of arsenic*, of commerce. From this substance the metal may be obtained by heating it with charcoal. Metallic arsenic is exceedingly brittle, of a whitish colour, strong lustre, and crystalline structure. It sublimes at a much lower temperature than that at which it fuses. Its vapour possesses a strong odour, like that of garlic. It soon tarnishes by exposure to the air at common temperatures.

There are two compounds of arsenic with oxygen, which, as they combine with alkalies, earths, and metallic oxides, have received the names of arsenious and arsenic acid.

Arsenious Acid, or White Oxide of Arsenic.

This compound of arsenic and oxygen is extremely rare in nature, but may be obtained artificially by heating metallic arsenic in atmospheric air. The best reagent for the detection of arsenious acid is sulphuretted hydrogen.

Sulphuretted Hydrogen produces in arsenious solutions a yellow precipitate, which is orpiment, or sulphuret of arsenic. As this precipitate is soluble in potassa or ammonia, it is necessary, in order to prevent any fallacy from the presence of an alkali, that the solution should first be acidulated with acetic or muriatic acid. The solubility of this precipitate in potassa and ammonia distinguishes it from the yellow solution occasioned by sulphuretted hydrogen in solutions of oxide of cadmium. The sulphuret of arsenic may be also distinguished by means of the *blowpipe*. When heated to redness with the black flux in a glass tube closed at one end, a metallic crust, of an iron-gray colour externally, and crystalline on its inner surface, condenses in the upper part of the tube, and yields the peculiar alliaceous odour of arsenic when converted into vapour. Also, on holding the part of the tube where the arsenic adheres, about three-fourths of an inch above the flame of the spirit-lamp, the metal is slowly sublimed, and is converted into arsenious acid, which condenses on the tube in resplendent crystals.

Hydrosulphuret of Ammonia produces in neutral solutions of arsenites no precipitate, but on acidulating them with muriatic acid, a precipitate takes place, but not immediately. The production of this precipitate is accelerated by heat.

Nitrate of Silver.—A yellow precipitate. By this the arsenites in solution are distinguished from the arsenites which give with this reagent a brown precipitate.

Solutions of *Chloride of Calcium*, *Chloride of Barium*, *Lime-water*, *Acetate*, and *Nitrate of Lead*, all give white precipitates with compounds of arsenious acid; but they give precipitates of the same colour with phosphoric and some other acids.

The ammoniacal sulphate of copper, formed by adding ammonia to a solution of sulphate of copper till the precipitate at first occasioned by it is nearly redissolved, causes *with arsenious acid*, *a green precipitate*, used as a paint, and known in commerce by the name of *Scheele's green*. But all these tests are inferior to sulphuretted hydrogen.

Arsenic Acid.

This acid is more abundant in nature than the preceding. It combines with lime, and the oxides of iron, copper, and lead. The arseniates form some of the most beautiful ores of those metals, particularly of copper.

Sulphuretted Hydrogen.—In solutions of arseniates slightly acidulated with acetic or muriatic acid, the same yellow precipitate is produced as in solutions of the arsenites.

Nitrate of Silver.—A brown precipitate.

The salts, both of arsenious and arsenic acid in the solid state, with soda on charcoal in the inner flame, give out the alliaceous odour of the vapour of garlic. Heated with charcoal-powder, or black flux, in a glass tube closed at one end, they sublime, and deposit metallic arsenic on the cold part of the tube.

CHROMIUM = 32. Specific gravity, 5·9.

CHROMIUM has never been found in the metallic state. It occurs combined with oxygen, both as an oxide and an acid. As an oxide, it forms the colouring matter of the emerald. As an acid, it enters into combination with lead and iron, forming the chromates of those metals. Chromate of lead is a beautiful red mineral from Siberia, the analysis of which by Vauquelin led to the discovery of chromium in 1797. Chromate of iron occurs in France, North America, near Baltimore, and in Unst, one of the Shetland Isles, occasionally accompanied in the latter locality by green oxide of chrome. Serpentine is the rock in which it is found. The name of chromium is derived from its tendency to form coloured salts.

The metal has hitherto been procured only in very small quantities, by exposing the oxide of chromium, mixed with charcoal, to the heat of a smith's forge. The metal thus obtained is white, with a shade of yellow. It is brittle, infusible, and soluble with great difficulty in acids, even the nitromuriatic.

THE GREEN OXIDE.

THE oxide is green, infusible, insoluble in water, and readily soluble in acids, until ignited, when it resists the action of the most powerful acids. It communicates a beautiful emerald-green colour to borax or vitreous substances. Ignited with nitre, it forms chromic acid. The following are the precipitates occasioned in its solutions by reagents:—

1. *Potassa.*—In small quantities produces a green precipitate, which dissolves even in the cold in an excess of the precipitant, producing a green solution. Boiling again precipitates the oxide of chromium, and renders the solution colourless.

2. *Ammonia.*—A grayish-blue precipitate, appearing of a violet colour by candle-light.

3. *Carbonate and Bicarbonate of Potassa, and Carbonate of Ammonia.*—A light green precipitate, which, after a time, acquires a blueish colour, and by candle-light appears violet. An excess of the precipitant re-dissolves part of the precipitate, and causes the solution to be greenish at first, but, after a time, blueish.

4. *Hydrosulphuret of Ammonia.*—A greenish precipitate of oxide of chromium, both in neutral and acid solutions.

5. *Liquid sulphuretted Hydrogen, and sulphuretted Hydrogen Gas.*—No precipitate, either in acid or neutral solutions.

6. *Iodide of Potassium.*—A greenish-white precipitate, soluble in muriatic acid.

7. *Chromate of Potassa.*—In neutral solutions, an immediate yellow precipitate, the solution acquiring a brownish-yellow colour. In acidulated solutions the same effects are produced, but not until after the addition of ammonia.

Before the blowpipe compounds of chromium are easily recognised by the beautiful green colour they communicate to fluxes. With *microcosmic salt* the colour is equally green both in the outer and the inner flame. This distinguishes oxide of chromium from oxide of copper, which only gives a green glass in the outer flame. With soda on the platinum wire it produces in the exterior flame a dark orange glass, which becomes yellow and opaque as it cools; in the reducing flame it gives an opaque glass, which cools to a green colour. The blowpipe affords the best means for detecting small portions of chromium or its compounds. They may also be distinguished by the green colour of their solutions, and by their not being altered by liquid sulphuretted hydrogen.

TITANIUM = 32. Specific gravity, 5·3.

METALLIC titanium has never been met with in nature, but it has been found in the slag of iron-works, in cubic crystals, of a colour and lustre like that of burnished copper. They are not soluble in nitric or nitromuriatic acid, but are decomposed by ignition with nitrate of potassa.

There appear to be two oxides of titanium,—the protoxide, of a purple colour, supposed to exist in a state of purity in the mineral called *anatase*, and the peroxide, which is nearly pure, in the mineral called *titanite*, or *rutile*. From the property possessed by this compound of oxygen and titanium of uniting with alkalies, it has received of late the name of *titanic* acid.

When pure, it is quite white, infusible, and after ignition insoluble in acids. After fusion with carbonate of potassa, it is soluble in muriatic acid, but is precipitated by boiling. It is also precipitated by pure and carbonated potassa, soda, and, ammonia. A solution of gall-nuts causes an orange-coloured precipitate.

A bar of metallic zinc precipitates a purple-coloured powder from solutions of titanic acid.

Titanic acid, when precipitated from muriatic acid by boiling, has a tendency to run through the pores of the filter when washed with pure water, but this is prevented by slightly acidulating the water, or by the addition of a little alkali or a salt. *Before the blowpipe* titanic acid with *borax* on the platinum wire gives a colourless glass, which flaming renders milk-white. In the reducing flame, the glass assumes a dull amethystine hue. With *microcosmic salt* in the outer flame, it forms a transparent colourless glass. In the inner flame, it affords a glass, yellow while hot, red while cooling, and a blueish violet-colour when cold. With soda it effervesces and melts into a dull-yellow glass, which crystallizes when the blast is suspended, evolving considerable heat. It is not reducible by the blowpipe to the metallic state.

TUNGSTENUM = 96. Specific gravity, 17·4.

TUNGSTENUM occurs combined with oxygen as an acid which unites with lime and iron, constituting native tungstates of those substances.

Metallic tungstenum is procured by exposing tungstic acid with charcoal to a red heat. The metal thus procured is of a grayish-white colour, with considerable lustre. It is brittle, nearly as hard as steel, and less fusible than manganese. When heated to redness in the open air it takes fire, and tungstic acid is generated.

Tungstic acid may also be obtained by digesting tungstate of lime reduced to fine powder in nitric acid, or by the action of muriatic acid on wolfram—the native tungstate of iron and manganese. The tungstic acid falls down as a yellow powder, nitrate of lime being formed in the one case, and muriate of iron and manganese in the other. By these means may the presence of tungstic acid be detected in a mineral.

Before the blowpipe tungstic acid alone on charcoal or platinum foil becomes first brownish-yellow, and is then reduced to a brown oxide, and in the end becomes black, without fusing.

On the platinum wire with *borax* in the interior flame, it forms a colourless glass, not rendered opaque by flaming. If the proportion of the acid be large, the glass becomes dirty gray, and then reddish; with *microcosmic salt* in the interior flame, it forms a blue glass like that formed with cobalt, the colour of which disappears in the exterior flame, but returns in the inner. The presence of iron renders the glass blood-red, instead of blue, but the addition of tin counteracts the effect of the iron, and restores the blue colour. With soda on charcoal, the acid is reduced to metallic tungstenum in the form of a steel-gray powder with a metallic lustre.

URANIUM = 208. Specific gravity unknown.

URANIUM was discovered in 1789, by Klaproth, in a mineral from Saxony, called pechblende, consisting of protoxide of uranium and oxide of iron. The properties of metallic uranium are but little known, as it has only been obtained in the metallic state in very small quantities.

It was procured by passing hydrogen gas over protoxide of uranium heated in a glass tube. It had a crystalline appearance, a metallic lustre, and a reddish-brown colour. Its ores are but few; it occurs as an oxide or hydrate, and combined with sulphur in pechblende.

There are two oxides of uranium. The protoxide is of a dark greenish colour, and forms with acids salts which have a green colour. It is readily oxidized by nitric acid, yielding a yellow solution, which is a nitrate of the peroxide. The peroxide is yellow, as are most of its salts. It is precipitated as a yellow hydrate by the *pure alkalies*, and as a carbonate by the *carbonated alkalies*, but is redissolved in an excess of the precipitant. It gives no precipitate with *sulphuretted hydrogen*. With prussiate of potassa it gives a brownish-red precipitate, not unlike that produced by the same reagent in a solution of peroxide of copper.

Before the blowpipe oxide of uranium on charcoal alone becomes black, but does not fuse. With *borax* in the outer flame, it forms a glass of a yellowish-green colour; in the *inner* flame, the glass is colourless, or nearly so, containing black particles which appear to be metal partially reduced, and which again dissolve and colour the glass in the outer flame.

With *microcosmic salt* on platinum wire in the outer flame the glass produced is of a clear yellow colour when hot, greenish-yellow when cold. On charcoal in the inner flame it gives a bright-green glass both when hot and cold. With *soda* on charcoal it changes to a yellowish brown, but neither dissolves nor reduces.

The remaining metals—tellurium, molybdenum, cerium, palladium, columbium, osmium, vanadium, and iridium, are of such rare occurrence, or have hitherto been found in such remote parts of the world, that they are not likely to be met with by the young geologist, and therefore their chemical characters need not be enumerated in a work like this. Cadmium, tilatium, tungstenum, uranium, and chromium are also rare, but as they have all been found in Britain, it appeared advisable to point out the means by which they may be detected in any of their compounds. Platinum, though by no means a common metal, and hitherto found only in America and Asia, has been noticed on account of its peculiar properties and utility. It has never yet been met with in Europe; and the discovery of it, in however small quantity, in that region of the globe, would be attended with interest. It should be searched for in those alluvial deposits which contain particles of gold or titaniferous iron-sand.

We shall close this part of our subject with a brief notice of the reagents by which to ascertain the acid with which an alkali, earth, or metallic oxide is combined.

SULPHURIC ACID.

THE presence of sulphuric acid, in solution either in a free state, or as a sulphate soluble in water (that is, all sulphates except those of baryta, strontia, lime, and protoxide of lead), is ascertained by means of a solution of chloride of barium, or nitrate of baryta, which occasion a white precipitate of sulphate of baryta insoluble in acids.

The protosalts of lead likewise produce with sulphuric acid white precipitates, distinguished, by their insolubility in diluted nitric acid, from the white precipitates formed by protoxide of lead with other acids.

Sulphates insoluble in water, but soluble in acids, are to be dissolved in muriatic acid, and the addition of chloride of barium will produce a white insoluble precipitate of sulphate of baryta.

Sulphates insoluble or sparingly soluble in water and acids, are to be boiled in a solution of carbonate of potassa; the solution is filtered, supersaturated with muriatic acid, and then tested with a solution of chloride of barium. Before *the blowpipe* sulphuric acid is discovered in sulphates which do not contain a metallic oxide, by the reddish or orange colour which a clear colourless bead resulting from the fusion of soda and silica acquires when a small portion of sulphuret is added to it. It is also detected by the black stain left upon polished silver by the moistened mass produced by the fusion of a sulphate with soda on charcoal.

Sulphates containing a metallic oxide are to be heated on charcoal to expel the water of crystallization. The sulphate, reduced to powder, is to be mixed with pulverized charcoal, and heated in a small test-tube, closed at one end. Disengagement of sulphurous acid gas will then take place, which may be recognised, not only by its smell, but by bleaching paper stained with Brazil wood, and reddening litmus paper. Earthy sulphates do not disengage sulphurous acid gas under the above process.

SULPHUROUS ACID.

FREE sulphurous acid is detected in solution by the white precipitate of sulphur occasioned by liquid sulphuretted hydrogen; but if a sulphite be present in the solution, no precipitate of sulphur will take place until after the addition of muriatic or sulphuric acid, in order to decompose the sulphite by the stronger acid.

In the solid form the sulphites are known by the odour of sulphurous acid gas which they disengage when heated with muriatic or sulphuric acid.

Before the blowpipe sulphurous acid is discovered by the same processes as the sulphuric.

NITRIC ACID.

NITRIC acid is detected in solutions by the addition of a little gold leaf and muriatic acid to the solution of the supposed nitrate, and if, on heating the mixture, the gold leaf is dissolved, the solution acquiring a yellow colour, the presence of nitric acid is proved, because no acid but nitro-muriatic will act upon gold.

Another method is to add to the solution a little sulphuric acid, and then some crystals of protosulphuret of iron. On warming the mixture, it will acquire a blackish-brown colour near the crystals from the disengagement and solution of nitrous gas.

Very small quantities of nitric acid and of nitrates may be discovered by means of a *solution of indigo* in sulphuric acid, which is to be added in sufficient quantity to render the liquid feebly but decidedly blue. If, on boiling this mixture, it becomes bleached, or loses its blue colour, and becomes yellow, nitric acid is present. The latter appearance denotes the presence of a very small quantity of the acid.

Nitric acid may be detected in the solid nitrates, by mixing them with powdered charcoal, and placing them on some red-hot substance, when they deflagrate and discharge sparks.

A familiar example of the deflagration of a nitrate may be seen in the effects produced when saltpetre (nitrate of potassa) is thrown on burning coals. A substance may also be tested for nitrous acid, by mixing it in a test-tube with copper filings and sulphuric acid, when orange-yellow vapours of nitrous gas will be disengaged at the ordinary temperature.

MURIATIC ACID AND SOLID CHLORIDES.

MURIATIC acid is detected in solutions by the white flocculent precipitate occasioned by nitrate of silver, which turns violet by exposure to sunshine, is insoluble in acids, and soluble in ammonia.

The muriates and chlorides, in the solid state, are also known by the fumes of muriatic acid gas which they evolve during their decomposition by strong sulphuric acid. On bringing a stopper or glass rod moistened with ammonia in contact with these fumes, dense white clouds of muriate of ammonia are produced.

Before the blowpipe the chlorides may be known by melting oxide of copper and microscomic salt into a green bead; to this the assay is to be added, and the presence of muriatic acid will be shown by the blueish-purple flame with which the globule will be surrounded on again exposing it to the blast.

CARBONIC ACID.

THE carbonates are easily distinguished by being decomposed with effervescence from the disengagement of an inodorous gas (which is carbonic acid gas), when treated either in the dry state, or in solution with almost all the acids.

PHOSPHORIC ACID.

ALL the neutral phosphates, except those of the alkalies, are only sparingly soluble in water, but dissolve in an excess of phosphoric acid and in nitric acid.

The insoluble phosphates (of which those of lime, baryta, and lead are the most so,) may be dissolved by boiling them with a strong solution of a carbonated alkali. Phosphoric acid is not easily detected by the humid process. Precipitates are caused in solutions of the neutral phosphates of the alkalies by *chloride of barium*, *chloride of calcium*, *lime-water*, and *water of baryta*, and the precipitated phosphates are soluble in nitric and muriatic acid; but these precipitates are not easily distinguished from the precipitates formed by the above reagents with some other acids, and therefore the presence of phosphoric acid is not proved until the absence of those acids has been determined by other experiments.

Acetate, or nitrate of lead, also forms, with phosphoric acid, a white precipitate insoluble in acetic, soluble in nitric acid. The precipitated phosphate of lead, when fused in the outer flame of the blowpipe on charcoal, crystallizes as it cools, a property peculiar to the compound of phosphoric acid with lead.

Nitrate of silver produces in solutions of neutral phosphates of the alkalies, a yellow precipitate, soluble in nitric acid and in ammonia; and as all the acids which resemble phosphoric acid (except the arsenic) cause, with oxide of silver, precipitates of a different colour from this, nitrate of silver is one of the best tests of phosphoric acid in solution.

There is, however, but one property characteristic of phosphoric acid, and phosphoric acid alone, which is, that when combined with protoxide of lead, it forms a salt which, on being fused by the blowpipe, crystallizes as it cools.

BORACIC ACID.

BORACIC acid is distinguished by the green colour which it communicates to the flame of burning alcohol. The borate, reduced to powder, is to be moistened with sulphuric acid, and covered with alcohol, which is then inflamed. No chloride must be present, as the chlorides impart to the flame of burning alcohol a greenish colour, though of a somewhat bluer tinge than that produced by boracic acid.

HYDROFLUORIC ACID AND FLUORIDES.

THIS acid is easily recognised by its peculiar property of corroding glass. Solid fluorides are to be reduced to powder, and mixed with concentrated sulphuric acid in a platinum crucible. This is to be covered with a plate of glass, previously coated with wax, through which letters have been scratched, and, on cautiously heating the crucible, so as not to melt the wax, the glass will be found deeply corroded in those parts which are exposed to the action of the fumes of the hydrofluoric acid generated during the process. The same effect is produced on glass by solutions of the fluorides (if not too dilute) when mixed with sulphuric acid.

METEOROLOGY.

Seven Lectures on Meteorology.—By LUKE HOWARD, Gent., F.R.S., &c. *Pontefract*, J. Lucas.

THE author of this little work is celebrated among meteorologists for his classification and nomenclature of clouds, the merit of which is proved by its general adoption among all who cultivate the science; and there are few writers on the subject more often cited for accurate observations, and for data connected with atmospheric phenomena. A work, therefore, from Mr. Howard, on the subject of Meteorology, would naturally excite interest by its appearance, and we are gratified in finding that the volume before us will uphold the author's reputation. These Lectures contain a clear, familiar, and scientific explanation of the principles of Meteorology, and, to render the work useful as a text-book to lecturers and teachers, there are notes appended, containing instructions for making the experiments necessary to elucidate the subject, and descriptions of the apparatus that would be required. That, however, which constitutes the recommendation of the book, its popular nature, precludes our finding much to comment on, to readers who possess more than the most elementary knowledge of the subject. We remark, however, in turning over the pages, that Mr. Howard still adheres to certain hypotheses which have been given up by later meteorologists; as, for example, that meteoric masses, which fall to the earth, are the results of the combustion of gases produced from the earth's surface.

> "Certain it is, however, and ascertained on the most satisfactory evidence, that some of these bodies have let fall not merely single stones, but a whole shower of these, on the tracts over which they have passed: and the composition of such bodies, collected from various countries, as found by chemical analysis, has confirmed the opinion that they have all one common origin. Now, though some philosophers have preferred to make, even of the smaller meteors, very distant bodies, extraneous to our atmosphere; and have

brought the larger from the *moon* in the form of projectiles, there is very strong ground to presume that the white trains which falling-stars leave behind them (at some seasons and not at others), are in reality the *ashes* of the combustion of a mixed inflammable substance, chiefly gaseous; which residue, at first incandescent, gradually vanishes by cooling where it is left, and subsides unperceived through the air. Again, that the solid stones, which have the appearance of earthy concretions, suddenly formed in a heated medium and glazed by flame on the surface, are the cinders and slag of a still larger aërial fire; of a *furnace*, indeed, (for such was the aspect of the meteor of 1783), carried through the air with the apparent falling of burning coals from it, which become extinct in their descent.

"The composition of these *Meteorolites*, their history, and probable origin in vapours, carried up from the earth and fired aloft, would form of themselves a very interesting lecture, but which does not enter into the plan of my course. Suffice it to say, that though the stones in question have been ascertained to have fallen from the heavens by day, in various parts of the world, and from remote antiquity—it was not so easy (and yet modern observation has been found equal to this,) to prove their connexion with the *bolis*, moving through the air, and drawing flame behind it. This, however, being proved, with the fact that hydrogen gas is capable of dissolving various bodies, even iron: and that it is naturally evolved, mixed with carbon in the gaseous state, in very large quantities (even from every piece of stagnant water, in the autumnal season,) we have a right to presume that, on occasion, it is collected in vast fields, to be fired by electric explosions, or by some play of affinities in nature, of which we have not, as yet, a proper conception; and (the gases burning out) to let fall the earthly and metallic contents, precipitated and agglutinated as we find them in the aërolite. A meteor of such a nature, covering an extent of many acres in the atmosphere (as these do), may very well afford a brilliant light, and (though but slightly charged in proportion to the mass with solid matter) *also the residue of the combustion, which descends.* But a body of the size of the largest aërolite, coming solid from space into our atmosphere (admitting it to take fire on first entering), would form but an inconspicuous object in its descent."

We entertain great respect for Mr. Howard's talents as an observer and as a meteorologist, but we confess we are puzzled at his chemical tenets. Can he inform us of any proven instance of iron being held in solution by hydrogen, or by any gas? or being combined in any appreciable quantity with an aëriform substance without destroying its fluidity and gaseous properties? Mr. Howard leaves the strong point of the opposite argument untouched—the alloy of iron and nickel, invariably found in meteoric masses, and never, as yet, in terrestrial minerals. He also seems totally to reject the collected evidence on the periodical reappearance of asteroïds, bearing so strongly on this point, and the vague hypothesis adopted by him, can in no way account for the horizontal motion through our atmosphere of the meteoric masses alluded to.

As regards Meteorology, we are now arrived at that point in our progress at which all further advance is hopeless, till a vast mass of accurate and extensive observations is collected, to serve as material for working out some expressions for the complicated laws governing atmospheric phenomena. Unfortunately, to collect such observations requires considerable skill and patience, and presents little to incite those qualified for the task to undertake it. The astronomer, in multiplying observations connected with his pursuit, has the certain pleasure to look forward to, of finding the most striking confirmations of established laws from every such exertion, and the exquisite intellectual gratification of applying the most refined and beautiful analysis to work out the results, while the grandeur of the scenes he contemplates, and the lively hope of possibly becoming the discoverer of some unknown planet, some new nebula, or binary star, stimulates and cheers him in his task. So the naturalist, the geologist, the botanist, and other cultivators of science, find incentives without end to the prosecution of their researches, but registering hourly fluctuations of the barometer, thermometer, and experimenting with hygrometers, or rain-gauges, is but a tedious task, and can hold out no other premium but the consciousness of being usefully employed. Now it can hardly be expected that those competent to this task will undertake it, unless they derive some recompense that will induce them to waive their pretensions to any celebrity to which they might attain by other pursuits. It therefore belongs to scientific bodies, or more properly still, to governments, to establish well-endowed institutions for making continuous and accurate observations at several distant stations throughout their respective countries. Till this has been done without intermission for several years together, Meteorology must remain as it now is, a science of plausible hypothesis, instead of laws relating to natural phenomena, strictly founded by induction on accurate observations of facts.

ON THE STEAM-ENGINE.

BY M. ARAGO.

[*Continued from page* 20.]

1705. NEWCOMEN, CAWLEY, and SAVERY*.

THE draining-engine, known among engineers by the name of *Newcomen's*, or the *atmospheric engine*, was the first which rendered any essential service to the useful arts.

I may say that even in a great number of situations where fuel is not expensive, it is still in use, and no inducement has yet been found to substitute any other for it. Further, this engine, except in some important details in the construction which I shall point out as we proceed, is no other than the engine proposed in 1690 and 1695 by Papin, and which he had attempted on a small scale.

In fact, in one, the same as in the other, may be remarked a cylinder, or vertical metallic pump-barrel, closed at bottom, open at top, and a piston properly adapted and intended to traverse the whole length.

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[*] Thomas Newcomen and John Cawley were both inhabitants of the town of Dartmouth, in Devonshire. In the English biographies of the first, he is sometimes called an *ironmonger*, sometimes a *blacksmith*. The other was a glazier. Newcomen was a man of some information, and a literary correspondent of Hooke, the Secretary of the Royal Society, one of the most ingenious *savans* that England can boast of. It is not known whether the two partners took an equal share in the experiments of various kinds which led to the construction of the first *large* atmospheric engine.

In one, as in the other, the up-stroke of the piston is effected by a counterpoise, and the aqueous vapour then enters freely into the lower part of the cylinder and fills it. In the English engine, as in that of Papin, as soon as the up-stroke of the piston has terminated, and the vapour which had forced it has become condensed, a vacuum is produced throughout the whole of the space which the piston had passed through, and the atmosphere then causes it to descend. Papin announced that the condensation must be produced *by cold;* and it was by cold that Newcomen, Cawley, and Savery, got rid of the vapour which counterbalanced the atmospheric pressure. *Among several different contrivances that might be imagined to do this*, (these are the expressions contained in the *Recueil de Pièces*, p. 53,) the English mechanicians have adopted one, far preferable in a large engine to that which Papin himself employed in the experiments made with his small model. Instead of removing the fire, as was done in the latter, Newcomen, Cawley, and Savery, threw a copious quantity of cold water into the annular space comprised between the exterior sides of the cylinder and a second cylinder rather larger, which served as an envelope. The refrigeration was thus gradually transmitted through the whole thickness of the metal, and in a short time reached the vapour itself.

Papin's engine, thus modified as to the process of cooling the aqueous vapour, excited the attention of mining proprietors to the highest pitch, and appeared, from the first, to furnish an unexpected solution of a problem, the difficulty of which had been remarkably exhibited by the fruitless trials of Savery.

Newcomen and Cawley solicited a patent, but Savery objected to it, as he was already in possession of an exclusive privilege for the production of a vacuum by the refrigeration of vapour. In order to avoid all dispute, the patent was taken out in the names and for the profit of the three competitors, who thus assumed to themselves a project borrowed from Papin, the two first taking the idea of the *piston* steam-engine, the third that of condensation*.

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* In the arts, as in the sciences, the last comer is *supposed* to be cognizant of the works of his predecessors; all denial, every declaration to the contrary, is of no weight. The publication of the Memoirs written by Papin upon the atmospheric engine, being greatly anterior to the patents of Savery and of Newcomen, I could have no motive for examining whether the English engine is, or is not, a copy; according to the rule, it is a copy, because it resembles the engine of Papin, and because it came after it; but, in this particular case, it is further known that Newcomen was acquainted with the projects of our countryman. It is proved, in fact, by several notes found among the papers of Hooke, that the Dartmouth engineer had consulted this celebrated *savant* before undertaking his experiments, and also that, in the confidence of friendship, he admitted that it was really the French engine he intended to construct.—(*See* ROBISON; *A System, &c.*, vol. ii. p. 58.)[1]

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[1] [“Newcomen was a person of some reading, and was in particular acquainted with the person, writings, and projects of his countryman Dr. Hooke. There are to be found among Hooke's papers, in the possession of the Royal Society, some notes of observations, for the use of Newcomen his countryman, on Papin's boasted method of transmitting to a great distance the action of a mill by means of pipes. Papin's project was to employ the mill to work two air-pumps of great diameter; the cylinders of these pumps were to communicate by means of pipes, with equal cylinders furnished with pistons, in the neighbourhood of a distant mine; these pistons were to be connected by means of levers with the piston-rods of the mine. Therefore, when the piston of the air-pump at the mill was

In the commencement of the eighteenth century, the art of constructing large cylinders perfectly true, and that of adjusting moveable pistons to their interior which would hermetically close them, had made but little progress. Wherefore, in the engine of 1705, to prevent the escape of the vapour through the interval between the surface of the cylinder and the edges of the piston, the latter was constantly covered on its upper surface with a stratum of water, which ran into all the interstices and filled them. As an engine of this kind was at work under the observation of its makers, they saw, with extreme surprise, the piston descend, several times successively, much more rapidly than usual. This velocity appeared to them more remarkable, as the refrigeration produced by the current of cold water which ran down the whole length of the cylinder externally, had, up to that time, carried on the condensation of the interior vapour but very slowly. Upon examination, it was ascertained that, on that day, the operation had been effected in a manner very different from the usual one; the piston having accidentally received a small perforation, the water which covered it ran through, and fell *into the very interior of the cylinder, traversing the vapour in the form of drops*, cooling the latter, and thereby condensing it more rapidly.

From that time, atmospheric engines were furnished with an opening having a rose-headed disperser, from which the shower of cold water which is distributed within the body of the cylinder issued, and there condensed the vapour at the moment of the descent of the piston. External refrigeration was thence given up, and the strokes were much more rapid. This important improvement, like many others that could be referred to, was the result of a lucky chance. I very much regret that I am not able to state here which of the three partners it was whose inventive mind instantly seized, in the unexpected event which I have described, the principle of an improvement which may still be found in the engines of the present day, but tradition upon this point has conveyed nothing to us.

1769. James Watt[*].

Previous to the commencement of an analysis of the inventions of Watt, I ought perhaps to introduce here the titles of the several patents which

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drawn up by the mill, the corresponding piston at the side of the mine would be pressed down by the atmosphere, and thus would raise the piston-rod in the mine, and draw the water. It would appear from these notes, that Dr. Hooke had dissuaded Mr. Newcomen from erecting a machine on this principle, of which he had exposed the fallacy in several discourses before the Royal Society. "Could he (meaning Papin) make a speedy vacuum under your second piston, your work is done."—Robison; *System of Mechanical Philosophy*, vol. ii. p. 58. Trans.]

[*] James Watt was born at Greenock, in Scotland, in the year 1736; his parents were poor, but respectable. The extreme delicacy of his constitution seemed to forbid all hope of a long life. This unfortunate circumstance had at least this good effect in his case; it induced those habits of seclusion and application without which it is extremely rare that anything great is accomplished. Up to the age of sixteen, young Watt attended one of the public and gratuitous grammar-schools of Scotland. He was then put out by his parents as an apprentice in a small workshop, where compasses, balances, a few philosophical instruments, sun-dials, and fishing-tacklel were made. Here he remained four years, At length, a little later, he went to London. and engaged with a maker of mathematica, instruments. A particular job having

he obtained during his long and glorious career. The perusal of these titles would clearly exhibit the objects of the important improvements which this illustrious mechanician successively introduced into the machines of his predecessors; they would, on the other side, undeceive those persons who believe, without any foundation, that the steam-engine

obliged him to pass a whole winter's-day near the door of the workshop, he caught so violent a cold, that the medical men were not able entirely to remove its consequences. He now resolved to try the effects of his native air, and returned to Scotland, where he set up in a small way on his own account. In the year 1757, the University of Glasgow confided to Watt, then twenty-one years old, the duty of curator of their collection of models. In consequence of this appointment, he received from the university a residence in the college, with permission to continue his little business there. Robison was at that time a student of the university; he formed an intimacy with Watt, and intrusted to him the scheme he had conceived for the application of steam-engines to the traction of carriages, and engaged him to occupy himself with their improvement. The several attempts made by the mechanician in 1759, in 1761, and in 1762, led to no result, but in 1764 some new trials were more productive. Having been directed, merely as a workman, to repair an engine of Newcomen's, which belonged to the museum, Watt detected defects in it, which the smallness of the model rendered very apparent, but the existence of which in large engines was not the less certain, though they had never been pointed out. Such were the date and the origin of the improvements mentioned in the text. Several years, however, passed away before Watt could submit them to a decisive proof. In 1764 he left the university, after having married, and he followed, for a time, the profession of a land-surveyor. His first improved engine was not executed until 1768, but it was of large dimensions, the cylinder being eighteen inches in diameter. Dr. Roebuck, who, by some pecuniary advances, had furnished Watt with the means of completing this work, set up the new engine at Kinneil, on the shaft of a coal-mine belonging to the Duke of Hamilton. All these names appear to me to deserve preservation; they belong to history. In this same year, 1768, Watt solicited his first patent; he did not obtain it, however, until 1769. Finally, Matthew Boulton of Birmingham became his partner in 1772, after the voluntary retirement of Dr. Roebuck. The wealth of this manufacturer, the capacity and activity of his mind, the personal *connexions he had made* with a multitude of individuals belonging to every class of society, gave to the enterprise the most lively impulse. The privilege granted by the patent expired, however, before the new manufactory at *Soho* had returned any certain profits. Boulton applied to the government, urged the co-operation of his numerous friends, interested the court and the city in his projects, and, by the numerous and judicious steps which he took, obtained from parliament the prolongation of the original privilege until the year 1800. From this epoch, (1775), the partnership of Watt and Boulton was in the highest degree prosperous. The sterile slope of Soho, near Birmingham, where the eye of the traveller could scarcely discover the cabin of a gamekeeper, was covered with beautiful gardens, with sumptuous habitations, and with workshops, which, in regard to their extent, their importance, and the excellence of the works which were executed in them, became, in a short time, the first in Europe. The discoveries of Watt were of an application so immediate and so popular, that academical honours could add nothing to the fame of this great mechanician; but let us nevertheless remark, that the principal learned Societies, those of Edinburgh and of London, for instance, hastened to admit him among their members. The Institute of France, on its part, selected him in 1808 as one of their correspondents, and decreed to him in 1814 the highest honour they possess, by naming him one of their *eight* foreign associates.

Arrived at an advanced age, possessed of a splendid fortune—the fruit of his noble and laborious exertions, surrounded by the esteem and the respect of the whole world, Watt withdrew from business, and retired to his seat at Heathfield, near Birmingham. There, the patriarch of productive power of England, always as kind, modest, and retiring, as when, in the times of his youth, he dusted the apparatus of the University of Glasgow, his days flowed peacefully along in the society of a small number of friends. In 1817, Watt made a journey to Scotland. On his return his health began to decline, and at length, after a short illness, he died, on the 25th of August, 1819, at the age of 84. A statue is about to be erected in Birmingham, to Watt, at the public expense. The possessor of every distinguished name in the British dominions has shown a most honourable anxiety to have it enrolled in the list of subscribers.

of the present day was produced by a single person, and by a single effort; but the necessity of restricting this notice obliges me at once to enter into the subject.

THE CONDENSER.

IN order that the atmospheric engine, called *Newcomen's* may be really effective, it is necessary, first, that at the instant of the commencement of the descending movement of the piston, there should exist, in the whole of the lower part of the cylinder, the most perfect vacuum possible; secondly, that, during the ascending movement, the vapour which enters from the boiler into this same space, should lose none of the elastic force which, at the cost of a large quantity of coal, it has acquired.

The first condition rigorously demands that, at the moment of condensation, the injection-water shall cool the sides of the cylinder; without this, the vapour whose annihilation is desired would retain a considerable elasticity, and offer a great obstacle to the descending movement of the piston, a movement that must depend upon atmospheric pressure. The second condition requires, on the contrary, that these same sides should be very hot; in fact, the vapour of water at 212° of temperature retains, on entering a vessel, the whole of the elastic force which is due to it in the degree only that the sides of the vessel themselves have the same temperature of 212°. If the temperature of the sides be less, the entering vapour instantly loses its primitive heat, and a portion, more or less considerable, of the density or elastic force which it possessed; so that, during the descending movement of the piston, the sides of the metallic cylinder into which it rushes ought to be as cold as possible, if the condensation is to take place within this cylinder, while during the ascending movement it is, on the contrary, important that these very sides should be at 212°.

The cooling is obtained very simply by projecting the injection-water not only into the midst of the vapour, but also *on the sides* of the cylinder. In the heating of these sides, which must follow, let us inquire how it may be done, that it may be considerable and *instantaneous*. The entering vapour itself would in time produce the heating desired, but this would be only *in time*, and therefore, the ascending journeys of the piston being very slow, the engine would not accomplish per day the whole of the duty which, without this kind of obstruction, might be expected from it. Let us remark, in addition, that the vapour coming from the boiler can heat the cylinder only by a loss of its own heat, or by partial condensation; now, vapour is a costly article, even when the water from which it is produced costs nothing, for the fuel, by the aid of which the transformation is effected, is always expensive. In order that the great attention which is necessary to be given to this financial consideration may not be underrated, I shall observe that the quantity of vapour thus employed to heat the sides of the cylinder would fill, *many times*, the space which they enclose; so that the cost of vapour, or, which comes to the same, the cost of fuel, or, if it should be preferred, the pecuniary expense of setting the engine to work, would be *many times* less, if the necessity of these *consecutive* heatings and coolings which we have described could be removed. Such is precisely the problem that Watt has solved by a method which permits the cylinder to be always maintained at a temperature of 212°. All he found to be necessary in this object was:

To effect the condensation of the vapour in a separate vessel, entirely distinct from the cylinder, and between which there was no other communication than that of a small pipe.

Let us explain this ingenious contrivance, which will ever constitute the principal title of Watt to the gratitude of posterity.

If there exist a free communication between a cylinder which is filled with vapour and a vessel exhausted of vapour and of air, part of the vapour of the cylinder will rush rapidly into the vessel. This transfer will not cease until the instant when the elasticity shall be alike throughout.

Let us suppose that the whole interior space of the vessel and its sides are maintained constantly cold, by means of an abundant and continuous injection of water; in this case, *all the vapour* with which the cylinder was originally filled will be then successively annihilated; the cylinder will be thus found to be cleared out of its vapour, *without its sides having been cooled the least in the world*, and the new vapour with which it becomes necessary to fill it in the succeeding instant will, in it, lose nothing of its elasticity.

A vessel separated from a cylinder, and into which the vapour from the latter enters from time to time, and is there precipitated, is called a *condenser*. It is the most valuable part of the engine of Watt.

The vessel, or *condenser*, which we have now got into action, cannot entirely absorb the vapour with which the cylinder was filled, except it contains cold water, and the remainder of its space is free from elastic fluids*.

The condensation once effected, these two conditions of success no longer exist; the condensing water has become heated by the absorption of the whole caloric of the water. A notable quantity of vapour has been formed at the expense of this heated water; and lastly, atmospheric air contained in the cold water has been disengaged during the heating of it. If, after each operation, this water, this vapour, and this air, which the condenser contains, be not removed, there will be at length an end to its effect. Watt accomplished this triple evacuation by means of the common instrument called *the air-pump*, the piston of which was properly attached by a rod to the working-beam of the engine. When a calculation is made of the effect of one of Watt's steam-engines, it is therefore necessary to have regard to the amount of power which is applied to maintain the air-pump in action. This deduction is, however, but a small part of the loss which, in the old method, followed the condensation of the vapour by the cooled sides of the cylinder†.

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* Strictly speaking, a vessel is never entirely free from elastic fluid so long as it contains water; for water, in the coldest state, throws out vapour; but when the injection-water is not of a temperature superior to the ordinary temperature of the atmosphere, the vapour exhaling from it may be neglected in practice.

† A correct idea of the commercial importance of the invention of the condenser may be acquired by a perusal of the few lines which follow.

For the grant of permission to substitute their engines for those which were called *Newcomen's*, Watt and Boulton required the value of *one-third of the quantity of coal*

Double-acting Engines.

In the atmospheric engine, whether the injection-water acts in the midst of the cylinder, or in a separate condenser, there is no effective power, except during the descending movement of the piston. It is then, and then only, that the weight of the atmosphere produces the whole of its effect.

During the ascending stroke, this weight is counterpoised by the pressure of the vapour which forces the piston upwards. The movement is then determined solely by a counterpoise which scarcely exceeds the weight of the piston, by the amount of the friction which takes place between the latter and the sides of the cylinder. This is not an evil, when the steam-engine is employed to lift water from inundated mines. The descending movement of the piston produces, in fact, a movement in the same direction of the extremity of the beam to which its rod is attached, and, therefore, an *ascending* movement in the other extremity. Now, it is during this latter movement that the water which is vertically beneath this second extremity of the beam, is raised in a quantity equal to the stroke of the piston in the great cylinder. When the piston of the draining cylinder descends,—when it proceeds to charge itself again with water, it would be perfectly useless to drive it violently. The power which would be so expended, would be power thrown away. Who has not observed (and the analogy is really perfect), that wherever water is drawn from a well, the bucket is left to descend by its own weight? that no one has entertained the notion of producing this descending movement by the action of the motor? Therefore, as a means of draining, the atmospheric engine is perfect; its intermittences of action are consequently no defect. The case is different when this engine is employed as a motor. The machinery, and the tools it puts in action, have very rapid movements during the descending course, but during the ascending movement, they either stop, or continue to act only in consequence of the velocity which they have previously acquired. A steam-engine which should act during the *two* opposite movements of the piston, would, therefore, present some real advantages. Such is the engine invented by Watt, and which is called *the double-acting engine.*

In this engine, the atmosphere is no longer an agent. The cylinder is closed at top by a metallic cap, perforated in its centre only by an aperture which is furnished with a stuffing-box, perfectly tight, through which the cylindrical rod of the piston moves freely, without permitting

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saved by each new engine in performing equal duty.

A preliminary experiment made with two engines, one of each kind, having precisely the same dimensions, showed, for example, the amount of the saving per each thousand strokes of the piston. A simple proportion would then give the remuneration in question, as soon as the number of strokes made by each engine per month was ascertained. Watt and Boulton obtained this number by a mall piece of clock-work attached to the working beam, and so adjusted that each of its movements pushed the index forward one division. This mechanism, or *counter*, was enclosed in a box which had two keys, and was opened on the day of reckoning, in presence of the agent of the inventors and of the overseer of the mine. The proprietors of Chacewater mine, in Cornwall, where three engines were employed, paid for the license of the inventors an annual sum of £2400, a proof that the substitution of the condenser for the injection which had been previously made within the cylinder, produced a saving of fuel equal to more than £7200 per annum.

the passage either of air or of vapour. The piston divides the pump-barrel into two spaces, which are closed and distinct. When it is intended to descend, the vapour from the boiler enters freely into the superior space by a pipe properly adapted for this purpose, and forces the piston downwards, in the manner which the atmosphere did in the atmospheric engine. This movement will meet with no obstacle, provided that, during its operation, the lower part of the cylinder, and this lower part only, is in communication with the condenser. Immediately the piston has completely descended, this state of things is entirely reversed by the simple movement of two stop-cocks. Then the vapour given out by the boiler can pass only below the piston which it is about to elevate, and the upper vapour, which, the instant before, produced the descending movement, rushes to, and is liquefied in, the condenser, with which, in its turn, it is in free communication. As soon as the piston has arrived at the summit of its stroke, the reverse movement of the same cocks replaces every part in its primitive state. The engine thus acts indefinitely, with a power nearly equal, whether the piston rises or descends; but, it is important to remark, the expenditure of vapour is precisely double to that which an atmospheric, or single-acting engine, would have occasioned*.

EXPANSION-ENGINES.

IN the double-acting engines which I have just described, the piston is forced alternately upwards and downwards by the vapour. If the boiler be in free communication with the cylinder, *during the whole time* required by each of these movements, the piston will be exposed to the action of a constantly-accelerating force; it will therefore reach both the extremities of the vertical cylinder in which it travels with a very great velocity, and which, without producing any useful effect, might affect the stability of the whole apparatus. If, on the contrary, the cocks attached to the two pipes which maintain the communication between the boiler and the cylinder, do not remain open during the whole time of the stroke of the piston, if, for example, they are closed, each in its turn, when the piston has passed through two-thirds of its stroke, the remaining third will be travelled through in virtue of the acquired velocity, and, principally, by the action which the vapour already let in will continue to exert. This action will become less and less strong during this last third of the movement of the piston, seeing that the vapour will expand gradually, and that in the degree that it occupies a space gradually increasing, its elasticity, like that of every other gas, will diminish. There will be, consequently, no injurious velocity at either limit of the stroke of the piston; and, which is yet more important, a less quantity of vapour will be employed to produce the desired effect. Who cannot see, in fact, that if the cock were open during the whole stroke of the piston, the injection would each time destroy a volume of vapour equal to that of the cylinder, and of a density equal to that of the vapour of the boiler; while, if the cock be closed when the piston is at two-thirds of its stroke, there will enter and be destroyed one-third less of vapour? Mechanicians have instanced experiments from which it would appear that, in thus employing *the expansion* of the vapour, considerable economy of fuel may be effected and the action still be equal. They have, therefore, recorded this proposition, which Watt inserted in his first patent, as one of the most brilliant of those for which the productive arts are indebted to him. It, however, does not appear that, in the greater part of the engines which were made at Soho, that expansion was ever employed on a large scale; recourse being had to it only to render the stroke of the piston a little more uniform.

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* Papin, as I have previously said, had, in 1695, clearly foreseen that steam-engines would not always be confined to the drainage of mines. He had already, at that epoch, pointed out how the piston-rod might be connected with the axis of a rotatory wheel, and the rectilinear movement of the alternating stroke of the rod be changed into the rotatory movement of the wheel. His attention was also drawn to the defect of continuity in the action of the atmospheric engine. In order to avoid producing the action of his wheel by impulsions of too violent a character, he proposed to apply to its axis two, or even a greater number of rods, attached to pistons working in distinct cylinders, and so adjusted that, in the case of two, for instance, the rod of the first should descend while the second was rising, and reciprocally. Two cylinders of an atmospheric engine so combined, produced an effect exactly the same as that of Watt's engine. The expenditure of vapour would be also precisely the same. The idea of constructing a double-acting engine by means of two distinct cylinders, was offered by Dr. Falck as a novelty, in 1779.

ENVELOPE, OR JACKET OF THE CYLINDER.

THE *isolated condenser*, the most beautiful of the inventions of Watt, is intended, as has been seen, to preserve the cylinder constantly at the temperature of the vapour, in order that the latter may not suffer a partial condensation when it enters the cylinder from the boiler. But this cylinder is in contact with the atmosphere throughout the whole extent of its external surface. Upon this surface, therefore, and consequently throughout the thickness of the cylinder, there will operate a perpetual refrigeration, for which the acting vapour must provide at the cost of its elasticity. Watt proposed to diminish this effect, by surrounding the first cylinder with a second one. An envelope of this kind, if it be closed at both ends, would prevent the formation of cooling *currents* of air, and this would be a considerable gain. But further, vapour might be introduced into the annular space enclosed between the two cylinders, and then the temperature of the cylinder will be so little different from that of the vapour furnished by the boiler, that, in practice, they may be considered as perfectly equal.

HIGH-PRESSURE ENGINES.

THE engines which have been described do not require that the vapour which puts them in action should have a pressure superior to that of the atmosphere. In order to get rid of the vapour when it has operated, it is only necessary to condense it. This process requires an abundant quantity of cold water, which, in many localities, is a serious difficulty. Locomotive engines adapted to the drawing of carriages on railways, have never been dreamt of on this system of construction. They would have, in fact, to carry with them not only the fuel for the supply of the furnace, not only the water which must constantly replace that which is gradually vaporized in the boiler, but also an enormous quantity of cold water for the purpose of condensation. Such an engine would not be capable of any great effort; it would scarcely move itself. The desire of removing the necessity of the condensing the vapour, has put a high value upon high-pressure engines.

In these engines, when, for example, the vapour has forced the piston upwards, it escapes, by the opening of a cock, into the air. As the difference of elasticity determines this effluence, it ceases when the pressure of the internal vapour no longer exceeds that of the atmosphere. So that, in this case, the cylinder is not entirely exhausted, as it is in that of injection. The vapour which, after the up-stroke, would have to force the piston downwards, will have, therefore, to overcome a resistance equal to the atmospheric pressure, before it can produce any useful effect. The same remark applies to the up-stroke, for at the moment of its operation, the upper part of the cylinder would be filled with vapour, and so on successively.

Papin was the first person who constructed an engine in which high-pressure vapour escaped into the atmosphere after having operated. This engine was intended exclusively to lift water. Leopold, who published it, described one of the same kind, in 1724, in his *Theatrum Machin. hydraul.* This had *a piston and a working-beam*, but was single-acting. At length, in 1802, Messrs. Trevithick and Vivian obtained, in England, a patent for a double-acting high-pressure engine, which has been applied by them, and by other persons, to the drawing of carriages upon railways. Watt, in his first patent, of 1769, had already reserved the right, "pour le cas où l'eau froide serait rare, de faire marcher les machines à l'aide de la seule vapeur, laquelle pourrait s'echapper dans l'air après qu'elle aurait produit son effet *." But it does not appear that there was ever constructed in his establishment a single engine upon this principle.

HIGH-PRESSURE CONDENSING ENGINES.

THERE are high-pressure engines, in which the vapour is condensed after it has operated, in the same manner as in the single-acting engines.

The engines of this kind which are in greatest esteem, are those which Mr. Arthur Woolf proposed in 1804, but they could not be applied to locomotive apparatus. In the engines of this engineer, highly elastic vapour, coming directly from the boiler, first enters an ante-cylinder, sometimes above, sometimes below, as in the double-acting engine. The only condition is, that the vapour is not condensed immediately on the arrival of the piston at either of the two extremities of the stroke. Mr. Woolf makes a further use of it, before its annihilation; and he does it in this manner. By the side of the ante-cylinder, there is a second, of about the same height, *but of a larger diameter*. The upper part of the first communicates by a pipe with the lower part of the second, and reciprocally. When the vapour has forced the piston of the ante-cylinder to the bottom of its stroke, and at the precise moment when this piston begins to rise by the action of the new vapour, coming directly from the boiler, and forcing it *upwards*, all the vapour which has already produced the first down-stroke, and which fills the cylinder into which it entered, expands into the second cylinder, beneath its piston, and forces it *upwards*. Thus the two pistons move in the same direction. As soon as this stroke is completed, the expanded vapour which filled the whole space of the broad cylinder is liquefied in an isolated condenser. A new portion of vapour coming from the boiler, then enters into the *upper part* of the ante-cylinder, and forces its piston *downwards*. The old vapour, with which the lower part of this cylinder was filled during the first stroke, passes, by expanding itself *above* the piston of the second cylinder, and forces it to *descend*, so that the two pistons, in this case also, move in the same direction. If each piston carries a vertical rod, and if these two rods are attached to two points in the working-beam, situated on the same side of its centre of rotation, the oscillations which this beam will describe, will be produced by the *combined impulses of the two pistons;* the same vapour will, therefore, have produced two effects previous to its condensation.

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* ["In cases where cold water cannot be had in plenty, the steam-engines may be wrought by this force of steam only, by discharging the steam into the open air after it has done its office."—WATT. *Specification of Patent*, dated 5th Jan. 1769. TRANS.]

This engine of Woolf is really an expansion-engine, very similar to that which Mr. Hornblower described in his patent of 1781. It is not evident, *à priori*, why the expansion of the vapour, working it as Watt proposed, in a single cylinder, should not produce as much effect as in following the system of Woolf. Experiments published in the monthly reports of the Cornish mines, appear, it is true, very much in favour of this system, but they ought not to receive universal assent until they shall have been made under the same circumstances, in all respects except that of the expansion of the vapour.

STEAM-BOATS.

THE application of steam-engines to navigation is, of all the inventions of modern mechanicians, that which, in certain countries,—America for instance,—seems likely to produce the most important results. The question of priority has, therefore, been the subject of highly animated controversy; from the very beginning, France has been put out of the question: the discussion appeared to be confined to the English and to the North Americans. The latter gave its application to Fulton: the English produced the papers, long anterior, of Jonathan Hull and of Patrick Miller. The argument is unanswerable with regard to Fulton; but does there not exist works still older than those of Jonathan Hull*, and in which the ideas of this mechanician are already registered? The reader shall judge if my researches in this respect have been fruitless.

The work of Jonathan Hull was in 1737. This is a translation of the title:—"Description et Figure d'un Machine nouvellement inventée pour amener les navires et les vaisseaux dans les rades, les ports et les rivières, ou pour les en faire sortir contre le vent et la marée, ou par un temps calme, à l'occasion de laquelle S. M. Georges II. a accordé des lettres-patentes au profit de l'auteur, qui on jouira l'espace de 14 ans; par JONATHAN HULL†."

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* [He writes himself "Hulls." TRANS.]

† ["A Description and Draught of a new-invented Machine for carrying vessels or ships out of, or into any harbour, port, or coast, against wind and tide, or in a calm. For which his Majesty has granted letters

This work contains, first, the figure and the description of two paddle-wheels placed in the stern of a vessel; the author proposes to substitute these wheels for the common oars; secondly, the proposition to turn the axes of the wheels by means of Newcomen's engine, then well known, but rarely employed, according to Hull's own expressions, pour elever de l'eau à l'aide du feu, [*with which he* (Newcomen) *raises water by fire.**]

The work of Patrick Miller appeared at Edinburgh in 1787. In it also may be found a description of paddle-wheels, considered as a means of propelling boats in canals, and a notice of the attempts which the author had made to make these wheels revolve properly. The latter article concludes with the following remark:—"J'ai quelque raison de croire que la force de la machine à vapeur peut etre employée pour faire tourner les roues, de manière à leur donner un mouvement plus prompt, et à augmenter conséquemment la vitesse du bateau†."

The above are all the passages that English critics have advanced, as the oldest and most explicit, in the discussions they have had with their American antagonists‡. I shall now proceed to furnish my contingent.

The work of Papin, that I have so often referred to, the *Recueil de* 1695, contains, *literally*, the following passages, at pp. 57, 58, 59, and 60: "It would be too long to relate here in what manner this invention (that of the atmospheric steam-engine) may be applied to lift water from mine, *to throw bombs*, *to row againt the wind* . . . . . I cannot, however, refrain from remarking how much this power would be preferable to that of galley-rowers for going quickly at sea." A critique on animal-motors then follows; these occupy, he says, a large space, and consume much, even when they are not at work. He remarks that his pipes (his cylinders) would be less troublesome; "but as they could not," he says, "conveniently work the common oars, revolving ones must be made use of." Papin relates that he had seen similar oars attached to an axis upon a bark of Prince Robert, and which were made to revolve by horses. With regard to himself, as it was the alternate movement of his piston that he wished to change into one of rotation, he undertook it in this manner:—"A part (*les manches*) of the pistons was toothed in order to turn small toothed wheels, fixed upon the axes of the oars." But as a piston does not produce any useful effect below its stroke, in order that the rotatory movement may be continuous, he proposed to employ

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patent for the sole benefit of the author, for the space of fourteen years. By Jonathan Hulls. London: Printed for the author, 1737."—Trans.]

* ["In some convenient part of the tow-boat there is placed a vessel about two-thirds full of water, with the top close shut; this vessel being kept boiling, rarefies the water into a steam, this steam being conveyed through a large pipe into a cylindrical vessel, and there condensed, makes a vacuum, which causes the weight of the atmosphere to press on this vessel, and so *presses down a piston* that is fitted into this cylindrical vessel, in the same manner as in *Mr. Newcomen's* with which he raises water by fire."—Hull's *Description*, p. 40. Trans.]

† ["I have also reason to believe that the power of the steam-engine may be employed to work the wheels, so as to give them a greater motion, and, consequently, to increase that of the ship."—Miller; *Experiments on Triple Vessels*, &c. 1787, quoted in *Quarterly Review*, 1818. Trans.]

‡ See the *Quarterly Review* for 1818. Vol. XIX., pp. 353 and 356.

several cylinders in which the pistons should move in opposite directions, one commencing to descend when another should have arrived at the lower end of its stroke, &c.

"But perhaps it may be objected," adds Papin, "that the teeth on the pistons (the racks) being engaged in the teeth of the wheels would, in rising and falling, give opposite movements to the axes, and that in this way the rising pistons would prevent the movement of the descending ones, or that those which descend would impede the movement of those which should rise. But this objection is easily removed, for it is a very common thing among clock-makers to fix toothed wheels on arbors or axes, in such a way, that being acted upon in one direction, they necessarily turn the axis with them; but when on the other, they turn freely, without communicating any motion to the axis, which may thus have a movement quite the reverse of the aforesaid wheels. The whole of the greatest difficulty consists, therefore, simply in establishing a manufactory for producing with facility light tubes, large, and equal from one end to the other," &c.

Papin had therefore proposed, in a printed work, to propel vessels by means of the steam-engine forty-two years before Jonathan Hull, who is considered, in England, as the inventor.

The mode pointed out by Papin for changing the rectilineal movement of the piston into a movement of continuous rotation, is not inferior, I believe, to that of the English mechanician; for, in the latter, the wheels attached to the principal axis and the paddle wheels are connected with each other by cords only.

The two cylinders, acting alternatively, with which Papin conceived he could regulate the movement of the wheels, are not so contemptible as may be imagined. Mr. Maudslay, one of the most skilful constructors that England possesses, has recently employed them in several of his large boats, as a substitute for the fly-wheel, which cannot be put up in a restricted space without great difficulty.

The substitution of a paddle-wheel for the common oars belongs neither to Papin nor to Hull; for, without speaking of the bark of Prince Robert, referred to by the former, we may find, in very old authors, evident proofs of the employment of wheels.

As to the first exact experiments on which a judgment may be formed of the relative advantages of this means of impulsion, they are not much older than the year 1699, and we are indebted for them to M. du Quet*.—*See* Mach. Appr. par l'Acad., Vol. I.

In treating of steam-engines, generally, I have endeavoured to distinguish between inventors, properly so called, and the engineers who were the first to execute them. If we now follow the same course, we shall find:—

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* The work of Mr. Robert Stuart (see p. 83, 3rd edit.) contains the following passage:—"Jonathan Hull doit être cité honorablement pour avoir indiqué des roues à palettes mues par une machine à vapeur, comme un moyen de faire marcher les navires sans vent et sans voiles. Ce project exigeait *la transformation* du mouvement retiligne et alternatif de la tige du piston, en un mouvement de rotation. Hull montra qu'une manivelle coudée donnait une solution ingénieuse du problème. On voit aujourd'hui, avec raison, dans cette invention, l'origine de l'introduction des machines à vapeur dans les usines, comme moteurs de toutes les variétés

That M. Perier was the first who, in 1775, constructed a steam-boat (a work of M. Ducrest, printed in 1777, contains the discussion of the experiments at which this engineer was present: their date is thus authentically established.)

possibles de mécaniques[1]." So that, in the opinion of Mr. Stuart, Jonathan Hull would have the two-fold merit of the invention of steam-boats and of having pointed out that the steam-engine could be substituted for the mechanical agents which had been employed up to his time in manufactories of every kind. I have but one objection to these conclusions: it is that the work of Papin, in which may be found the idea of the boats, and that of a continuous rotatory movement communicated to a wheel by a steam-engine, was forty-two years anterior to that of the engineer Hull.

An English *savant*, one of my friends, to whom I had made a verbal communication of the results which are contained in this notice, told me that if I ever published them, he would oppose all my assertions by passages taken from French authors. "This would be," added he, smiling, "a war of inverted commas." I entreated him to be more explicit, and discovered that the arguments with which he intended to encounter me would be drawn either from a biographical article on Newcomen, which we owe to one of the most illustrious *physiciens* of our day, or from a Report upon Steam-boats, compiled by the celebrated Professor of Mechanics at the *Conservatoire*, and approved by the *Académie des Sciences.* I am obliged to acknowledge that in these two articles the opinions of English authors as to the inventors of the steam-engine are adopted without reserve; the objection, therefore, has some weight, but it does not appear to me irremovable. So far as the article on Newcomen is concerned, I shall remark that it is evidently sketched out from Robison's *History.* But the distinguished writer to whom we owe it has nowhere stated that he had made, on this occasion, any particular inquiries, or consulted any original sources. If he had mentioned Salomon de Caus, I should, doubtless, have felt a scruple on the subject of the importance which it has appeared to me to be just to attach to the researches of this French mechanician; but his name is not once found in the biographical article, although there may be read, at full length, those of Worcester and of Savery. From this, I consider I may, with certainty, conclude that the works of Salomon de Caus, and I presume even those of Papin, were unknown to my learned fellow-member. His opinion I, therefore, cannot admit to be opposed to mine; for I have a right, like the ancient Greek philosopher, to appeal from Philip to Philip better informed. If I then proceed to the second objection, I shall easily remove the authority of the *Académie des Sciences*, by remarking that it is a constant rule with that body never to express an opinion, except upon the *conclusions* which may be drawn on the Reports presented to it. The developements, more or less extensive, which accompany these conclusions, are never taken into consideration at all by the Academy: the reporter alone is responsible for them. Now, the very detailed Report upon Steam-boats, which was read to the Academy on the 27th January, 1823, terminates in *conclusions*, in which I do not see a single word that has any reference to the inventors of the steam-engine; there is, therefore, no decision of the Academy which can be opposed to me. As to the body of the Report, I find there, it is true, that the English were the first to employ steam-power to raise water; that Worcester is the inventor whose ideas were developed by Savery; that it was Jonathan Hull who conceived that ships might be navigated by the aid of the steam-engine; but as I do not see either the name of Salomon de Caus, nor that of Papin, although, whether for good or for evil, they were occupied with these questions previous to the English mechanicians, I have a right to repeat here the reflections that the article in the *Biographie Universelle* has just suggested. Further, authorities, however respectable they may be, are of no importance in the present case. The question is reduced to the inquiry, are the works upon which I rely of the date which I have assigned to them, and are my extracts faithfully made? All the Academies in the world may have decided, by common

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[1] ["Although Mr. Jonathan Hulls did not originate any novelty in the construction of the Atmospheric Engine, he is entitled to the honourable notice of having proposed the application of paddle-wheels moved by a Steam-Engine, to propel ships, instead of wind and sails. *In this scheme it was necessary to convert the rectilineal motion of a piston-rod into a continuous rotatory one*, and which he ingeniously suggested might be accomplished by means of a *crank.* This is now with justice considered to be that invention which introduced the Steam-Engine as first mover of *every variety of machinery*."—STUART: *History of the Steam-Engine*, 1824, p. 83. TRANS.]

That attempts on a larger scale were made, in 1778, at Baume-les-Dames, par M. le Marquis de Jouffroy.

That in 1781, M. de Jouffroy, proceeding from experiment to practice, actually established upon the Saône a large boat of the same kind, which was not less than 148 feet in length, and 15 feet in breadth.

That the minister of the day transmitted to the *Académie des Sciences*, in 1783, the Report of the favourable results which had been obtained by this boat, with the view of ascertaining whether M. de Jouffroy had a right to the exclusive privilege which he requested*. (MM. Borda and Perier were the commissioners appointed.)

That the attempts made in England by Mr. Miller, Lord Stanhope, and Mr. Symington, are of a much later date; (the first must be referred to the year 1791; those of Lord Stanhope, to 1795; and the experiment made by Symington on a canal in Scotland, to the year 1801.)

That, finally, the trials of Messrs. Livingston and Fulton, not being earlier than 1803, have less pretension to the title of an invention, as Fulton had had, in England, a minute acquaintance with the attempts of Messrs. Symington and Miller, and that several of his countrymen, Mr. Fitch among others, had made public experiments on this subject in the year 1786. Let us, nevertheless, state that the first steam-boat which was not abandoned after it had been attempted,—that the first which was applied to the transport of passengers and goods, was that which Fulton constructed at New York in 1807, and which made the voyage from that city to Albany. In England the first steam-boat that was seen in activity for the convenience of commerce and passengers has the date of 1812 only; it navigated the Clyde, and was called the *Comet*. The second was in 1813, and made the trip from Yarmouth to Norwich.

Contrivances by which the Steam-Engine is rendered self-acting and independent of any attendant.

The first engines of Newcomen required the constant attendance of a person to open and shut, at the proper moment and alternately, various cocks, sometimes to let the aqueous vapour into the cylinder, sometimes to inject into it the water destined for condensation. Tradition ascribes to a child, named Humphrey Potter, the first invention of the mechanism by the aid of which the engine itself turns the cocks at the instant required. It is stated that Potter, being one day vexed that he could not go and play with his companions, thought of attaching the ends of some strings to the handles of the two cocks which it was his duty to open and shut; the other ends being attached to the working-beam, the pull that this produced in rising and falling acted instead of

consent, that Worcester was the first who thought of driving water by the elastic force of vapour; still it would not remain less a fact, that the idea belongs to Salomon de Caus, for 1615 was before 1663. Again, until it shall be proved that the year 1695 followed that of 1736, Papin, in spite of the authority of all Reports present, past, and future, will have the merit of having proposed steam-boats forty-two years before his competitor, Jonathan Hull.

* The boat attempted at Lyons contained two distinct steam-engines. The events of the Revolution obliged M. de Jouffroy to emigrate, and all his experiments led to nothing.

the efforts of the hand. Beighton, the engineer, very much improved upon this first idea, by fixing vertically upon the beam a rod of wood, called in English the *plug-frame*. This rod was furnished with several pins, which struck at the proper instants, determined by the working of the beam, the rods of various valves. The mechanism of Beighton was adopted by Watt with some advantageous modifications. At the present time, the distribution of the vapour into the several parts of the cylinder is effected by a more simple means, which renders the plug-frame entirely unnecessary, at least in those engines, the power of which is not excessive, and which are intended to turn an axis. This means, which I shall not attempt to describe here, and which, without figures, would, perhaps, be unintelligible, is called a *slide-valve*. An eccentric wheel attached to the arbor which the engine is to turn, gives two opposite movements to the slide-valve during each of its revolutions: these two movements are sufficient to introduce the vapour from the boiler, above and below the piston, successively, and to open, for that which has already operated, a proper passage towards the condenser.

The mechanism of the slide-valve and of its eccentric was conceived by Mr. Murray, of Leeds, in 1821.

In the high-pressure double-acting engines the vapour is introduced successively in the higher and in the lower part of the cylinder, and when it has produced its effect, is let off into the atmosphere. All this requires but a quarter turn of one and the same cock, known by the name of the *four-way* cock. This apparatus, which is extremely ingenious, is similarly employed at the present day in all the large water-engines erected in Germany. It is to Papin that the invention is owing; it may be seen in the high-pressure engine of this mechanician, of which Leopold has preserved the figure, and in that which Leopold himself proposed at a later date—viz., in 1724.

Crank and Fly-wheels.

Mr. Keane Fitzgerald published, in the *Philosophical Transactions* of 1758, p. 727 *and foll.*, the description of a mode adopted to change the alternating and rectilinear movement of the piston of a steam-engine into a continuous rotatory movement. He employed for this purpose a very complicated system of toothed wheels, among which were several of the ratchet-kind. As far as this, the mode of this engineer is the same as that of Papin; but he went further, and conceived the idea of adding a *fly-wheel* to his machinery: this was a most valuable means of regulating the motion of steam-engines, and is generally used in the present day; and it is but just we should render the honour of it to Mr. Keane Fitzgerald.

So long as the alternating movement of the beam of a steam-engine was communicated to a rotating axis, only by the intervention of toothed-wheels, breakages were likely, which were deplorable in themselves, but still more in consequence of the interruptions of work which they occasioned. In 1788, Mr. Washbrough, of Bristol, proposed to effect this communication by means of a bent handle, which was a part of the rotating axis: it was, as we see, merely to use the means previously employed in the old women's spinning-wheels, and in every knife-grinder's apparatus.

Nevertheless, a patent was taken out, a privilege was granted, and a contrivance that all the world could have used when the motor was a man's foot or a current of water, was forbidden to the engineer who used steam to propel his engine. In order to avoid the tax which he would have to pay to Mr. Washbrough for each of his engines, Watt made use in his practice, until the expiration of the patent which this latter possessed, of a mode of communication somewhat different. It was effected by a toothed wheel connected with the rotating axis, which he called *the sun-wheel*, because its centre remained fixed, and of another wheel similarly toothed, attached to the extremity of the shaft of the beam, and which, for distinction, he named *the planet-wheel*. It would be useless to describe this mechanism more minutely, for Watt himself returned to the simple crank as soon as it was in his power.

Means of preserving the Piston-rod in a Vertical Direction, and of connecting it with the Beam.

In the single-acting engines of Newcomen and of Watt, the beam is terminated by a circular arc; and a flexible chain, attached to that extremity of the arc which is farthest from the piston, is the only means of communication between these two parts of the apparatus. When the piston descended, by the atmospheric pressure, it drew down the beam. When the piston ascended, by the action of a counterpoise placed at the opposite extremity, then the beam drew up the piston. Now, a chain, situated between two points, however flexible it might be, is always an excellent means of effecting a pull; and therefore, in the single-acting engine its employment produced no difficulties.

With the double-acting engines it is a different case. In its descending movement, the piston certainly draws down the beam, but in the succeeding movement, or when the beam reascends, it must be *pushed* upwards; now, a flexible chain can never be used to push. The old machinery, therefore, required a modification in this point.

The first which was employed consisted in toothing that portion of the piston-rod which always remained out of the cylinder, to form it into an actual rack, and to engage it in a circular arc similarly toothed, fixed at the end of the beam. This was what Papin proposed in 1695.

Much later, Watt conceived a far more preferable method, and which is now generally adopted, particularly when there is no deficiency of room: it is that which has been called the *parallelogram-method*, or the *parallel motion*. It would be very difficult for me, in this place, to give, without figures, a description which should be complete. I shall be content to say, that a parallelogram, whose four angles are four hinged joints, and which, consequently, can take all kinds of forms without ceasing to be a parallelogram, is attached by its two superior angles to the beam of the engine; that the piston rod is attached to one of the interior angles, and that the fourth angle is attached to a rigid, inextensible rod, which can turn upon a fixed centre Whatever may be the position of this centre, the rod which proceeds from it must be of an invariable length, so that the parallelogram must necessarily be distorted during the oscillations of the beam, and so that it may sometimes be right-, sometimes oblique-angled. But, when the centre on which the rod acts is properly determined upon, (and it is in this that the discovery of Watt consists,) that angle of the moveable and varying parallelogram to which the piston-rod is attached, never departs sensibly from the vertical line during the oscillations of the beam. The piston-rod is thus perfectly guided, and its connexion with the beam being accomplished by the intervention of a rigid apparatus, it is equally adapted to *draw* the beam downwards during the descending stroke of the piston, and to *push* it upwards when the piston ascends.

The articulated parallelogram excites, in the highest degree, the attention of persons who see for the first time a steam-engine in action. To the eye of the practised mechanician, it presents an apparatus of easy execution, entirely exempt from jerks, and capable of an indefinite duration. It is incontestibly one of the most ingenious inventions of Watt. The patent in which it is found is dated in the month of April, 1784.

CENTRIFUGAL REGULATOR.

THE pipe which, in the machines of Watt, conveys the vapour from the boiler to the cylinder, incloses a thin disc or valve, resembling those which are inserted in the pipes of our stoves. In a certain position, the disc leaves the bore of the pipe almost entirely free; in another, the pipe is perfectly closed; in the intermediate positions, there is an aperture of greater or less dimensions, according as one or other of the two limits which I have just described are approached. The movements of the disc are rendered serviceable by means of the axis which is prolonged on the outside of the pipe.

If the valve be entirely open, the vapour fills the cylinder very rapidly; if it be nearly closed, a very long time, on the contrary, is necessary to effect the passage of the same quantity of vapour. Now, the number of seconds that are required for a stroke of the piston, depends evidently upon the rapidity with which the vapour rushes and presses upon one or other of its faces. The rotating valve of the pipe furnishes, therefore, up to a certain point, a means of regulating this velocity. If the axis which carries it is finished by an elbow, so as to form externally a crank, it is only necessary to turn it in one direction, or its opposite, in order to accelerate or retard the strokes of the piston. It would be necessary, for instance, that the crank rise, if the piston goes too quickly, and if it is wished to retard it,—that the crank descend, on the contrary, when the piston moves too slowly. In adapting to the engine a part which must necessarily rise when the motion is accelerated, and necessarily fall, when it is retarded, the problem is solved, for it is enough if this part be connected in any manner whatever to the crank of the valve. Such was the object of the mechanism which Watt called the *governor*, and which is now more generally named *the centrifugal regulator*, (*régulateur à force centrifuge*.) This apparatus consists of a vertical axis, which the engine turns round more or less rapidly, according as it goes itself quickly or slowly. On the superior extremity of this axis two metallic rods are hinged and suspended rather freely, in collars, so that they can depart more or less from a vertical line. Each rod carries at its lower end a large metallic ball. When the vertical axis is set a-going by the engine, the balls, which turn with it, are carried away from it within a certain limit, by the effect of their centrifugal force. If the motion is accelerated, the separation becomes greater; and it diminishes as it slackens. The balls, therefore, rise in the first case, and they descend in the second. These ascending and descending oscillations are communicated by rods to the crank of the rotating valve in the pipe which conveys the vapour, and all very considerable changes in the velocity of the engine are thus prevented.

This apparatus, composed of moveable rods carrying balls, this conical pendulum, (as it was formerly called,) had been employed very anciently as a regulator in flour-mills. It had also been used similarly to regulate the paddle-opening in streams intended to set a bucket-wheel in motion. This latter application was exactly similar in object and means to that which Watt gave it in the steam-engine in the year 1784.

SAFETY-VALVE.

THE fire beneath boilers of large engines is never so uniformly regulated as to avoid giving, from time to time, to the vapour with which these boilers are half-filled, an elastic force superior to any which the strength of their sides can resist.

To prevent this evil, and the dangerous explosions which are the consequence, is the object of the little apparatus which has been called, with propriety, a *safety-valve.*

The safety-valve was invented by Papin. It forms an essential part of his digester, and the description of it may be found in pages 6, 7, 8, 9, and 10 of a small work printed at Paris in 1682, under the title of *La Manière d'amollir les os, &c. &c*[*]. The mechanism of Papin is precisely that of the safety-valves which are the most generally used at the present time. Its principle, besides, is very simple.

If it be desired that a boiler should never be subjected interiorly to too strong a pressure, we must, to accomplish the object, cut a very small circular piece out of the side of the boiler; the hole which is thus made is covered by a disc truly made, and opening from within to without, exactly the same as if the corresponding portion of the boiler had become itself moveable. Suppose that the hole, for example, had a square half-inch of surface, Papin then calculated the pressure which a square half-inch of the boiler would be subjected to when the elasticity of the vapour within it should have attained the limit agreed upon; by this was found the weight with which the valve may be loaded, in order that it may not be lifted by any pressure which may be below this limit; and that, on the contrary, it may rise and give free passage to the vapour as soon as the limit in question is exceeded. This means would present some evils if the valve had a large opening; the pressure would then be rather strong, the weight with which it must be loaded would be very considerable, and the adjustment difficult. Papin, therefore, preferred the acting upon the moveable disc by the intervention of a lever. A moderate weight then sufficed to counterpoise the greatest pressures. This weight, suspended successively in notches cut along the lever, at various distances from the centre of rotation, like the beam of a steel-yard, could give variable and gradual pressures, among which the mechanician would select daily that which would be best adapted to the kind of work he wishes to execute.

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[*] In Robison's *History of the Steam-Engine*, which contains the notes of Watt, there is, at p. 48, the following paragraph: "Le docteur Papin, Français, inventa, vers ce temps-là (vers 1699) un moyen de dissoudre les os dans l'eau et autres matières animales solides, en les renfermant dans les vases parfaitement clos qu'il appelait *digesteurs.* Ce matières aquéraient aussi un grand degré de chaleur. Je dois observer ici que Hooke, le plus subtil expérimentateur d'un siècle si fécond en recherches ingénieuses, *avait trouvé* LONG TEMS AUPARAVANT, *c'est-a-dire en* 1684, que l'eau ne peut acquérir au-delà d'une certain température quand on la chauffe en plein air, et qu'aussitôt qu'elle commence à bouillir, elle marque toujours le même degré[1]." In order that this passage may be accurate, it would be necessary that *La Manière d'amollir les os* should not have been published in 1682, but as 1682 is really and truly the date of Papin's work, it becomes necessary to translate *the long time before* of Dr. Robison, into *some time after.* Arguments based upon arithmetic are irresistible.

[1] ["Captain Savery obtained his patent *after having actually erected* several machines, of which he gave a description in a book entitled *The Miners' Friend*, published in 1696, and in another work published in 1699. Much about this time, Dr. Papin, a Frenchman, and Fellow of the Royal Society, invented a method of dissolving bones and other animal solids in water, by confining them in close vessels, which he called DIGESTERS, so as to acquire a great degree of heat. For it must be observed in this place, that it had been discovered long before (in 1684) by Dr. Hooke, the most inquisitive experimental philosopher of that inquisitive age, that water could not be made to acquire above a certain temperature in the open air, and that as soon as it begins to boil, its temperature remains fixed."—ROBISON'S *System of Mechanical Philosophy*, Vol. II., p. 48. TRANS.]

I have entered into all these details relating to the safety-valve of Papin, because this little apparatus is of extreme importance; because it prevents, for the greater part, the disastrous accidents which inevitably took place in the explosion of boilers before its adoption, and because I have found in it another opportunity of doing that justice to our compatriot which had been, for a long time, denied him*.

At the time when the explosions of self-acting boilers demonstrated that an ordinary safety-valve could not be trusted without danger in inexperienced hands, it was sought to furnish these utensils with a means of *inevitably acting themselves*, whenever the temperature should become too high. For this purpose, an alloy, known among chemists by the name of *fusible metal*, and composed of bismuth, tin and lead, was selected. A portion of this alloy, adapted to the hole in the boiler, melted, and left the hole free, as soon as the vapour acquired an elasticity which was too powerful, or, which is the same thing, a temperature which was too high. Since this, the fusible plates have been applied in France to all the boilers of high-pressure engines, by order of the government. The degree of fusibility of the plate, which varies with the several metals which enter into its formation, is always previously regulated by the elasticity under which the constructor reports that his engine will work.

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* Partington asserts, in his interesting work, that even the early engines of Savery had a safety-valve, but he is in error; the figure inserted in the 22nd Vol. of the *Philosophical Transactions* has no trace of it. Granting this, it would be true that Papin would not be less the real inventor, for his *printed* description was in 1682; that the patent of Savery goes no further than 1698; and that the first trial of his engine before the Royal Society was in 1699.—(*Trans.* Vol. XXI., p. 288.)

I HAVE hitherto spoken only of those kinds of steam-engines which have been tested by long experience. I had an intention to devote a few pages to others which, it may be said, are as yet merely projected, such as rotatory engines, and engines by the explosion and liquefaction of gas, &c.; but the too-great extent which this notice has already acquired, obliges me to defer them. For the same reason I shall suppress the detailed considerations that I wished to insert on the best forms of boilers and of furnaces; on the presumed causes of the explosions which so frequently happen in boilers; on the most advantageous effects furnished by the most perfect engines known; on those that future improvements may bring to light, in judging by the information which has been acquired within a few years, on the properties of vapour, &c. If the excursion which I have now made from the field of astronomy and meteorology, within which the Notices of the *Annuaire* are generally confined, should not be considered out of order, I shall be able, in the next year, to complete the article. Until that time, I shall conclude by a succinct abstract of the several consequences which appear to me to flow from it.

1615. Salomon de Caus was the first who thought of using the *elastic force* of aqueous vapour in the construction of an hydraulic machine adapted to drainage.

1690. It was Papin who conceived the possibility of making a piston-steam-engine.

1690. It was Papin who combined for the first time, in the same piston-steam-engine, the elastic force of the vapour of water, with the property which this vapour possesses of condensation by cold.

1705. Newcomen, Cawley, and Savery, were the first to see that to obtain an instantaneous precipitation of aqueous vapour, it was necessary that the injection-water should be dispersed in drops through the mass of this vapour itself.

1769. Watt exhibited the immense economical advantages which were obtained, by substituting for the condensation which, before his time, was effected in the interior of the cylinder, that of the condensation in a separate vessel.

1769. Watt pointed out the effect that might be obtained by the expansion of aqueous vapour.

1690. Papin was the first to propose the use of a steam-engine to turn an arbor or a wheel, and to give the means of attaining this effect. Until him, steam-engines had been regarded as applicable to drainage only.

1690. Papin proposed the first double-acting steam-engine, but with two cylinders.

1769. Watt invented the first double-acting engine, and with a single cylinder.

Before 1710, Papin had conceived the first non-condensing high-pressure steam-engine.

1724. Leopold described the first piston-engine of this kind.

1801. The first high-pressure locomotive engines were due to Messrs. Trevithick and Vivian.

1690. Papin must be regarded as the real inventor of steam-boats.

Of the principal parts of which a steam-engine is composed:—

1718. Beighton invented the vertical rod moving with the beam, or the *plug-frame*, which opens and shuts the valves in large engines.

1758. Fitzgerald was the first to use a fly-wheel to regulate the rotatory motion communicated to an axis by a steam-engine.

1778. Washbrough employed the crank to convert the rectilinear movement of the piston into a rotatory movement.

1784. Watt conceived the parallel motion.

1784. Watt applied, with great advantage to his various machines, the centrifugal regulator, already known.

1801. Murray described and executed the first slide-valves moved by an excentric.

Before 1710, Papin invented the four-way-cock, which is of such important use in high-pressure engines.

1682. Papin invented the safety-valve.

PRACTICAL SCIENCE, APPLIED TO THE REFORM OF THE POST-OFFICE.

I. *Post-Office Reform.* By Rowland Hill, Esq.

II. *Ninth Report of the Commissioners of Post-Office Inquiry.*

There is no subject of more universal interest than the transmission of letters. Facility, despatch, punctuality, and cheapness in their conveyance are vitally important to the business, the welfare, and the enjoyment of all. The system of the Post-office should therefore be adapted to afford to commercial people particularly, and the public generally, all the benefit that can possibly be derived from the important changes that are daily taking place in the communications throughout the country.

The Post-office is a State monopoly. The necessary expense of conveying the letters is about one-fifth only of the postage that is paid. The remaining four-fifths are a tax, and a tax not only injurious by its excess, but, as recently pointed out in a very able pamphlet of Mr. Rowland Hill, very unfair in its operation.

There is no branch of revenue to which it is more important that practical and political science should be applied; and we might almost say that there is none from which it has been more rigidly excluded. The difficulties which Mr. Palmer encountered in carrying into effect the conveyance of letters by mail coaches instead of carts, and the long denial of his stipulated reward, were fatal discouragements to all interference from without, and the people within the office never stepped out of the drudgery of its details, except to recommend increased charges on the public.

Great as the aggregate interest of the public is in the judicious management of this royal monopoly, and in the moderate rate of charge *for the conveyance* of letters, that interest happens unfortunately to be so much subdivided, that, individually, it has been felt to be a less hardship to submit, than to undertake a contest with a public department, in which success could only be attained by persevering efforts, and great expenditure of time, temper, labour, and money; so that the system has worked *officially*, but how far *beneficially*, may be learnt by the fact that, while every other branch of revenue has increased, that of the Post-office has diminished, notwithstanding the spread of education, the increase of commerce and manufactures, the rapidity of intercourse, and the highly excited activity of the country.

But as in recent times we have experienced, by the enormous sale of cheap and good literary productions, and by the increasing millions who travel in omnibusses compared with the scores who before travelled by hackney coaches, that the public will take advantage of every facility and benefit that can be obtained at a cheap rate, Mr. Hill has recommended a different sort of remedy, and, most opportunely for the public interests, it happens that a tribunal is in existence, whose duty it is to inquire how far they may be left to the tender mercies of the Post-office department.

We allude to the Commission of Post-office Inquiry. Lord Duncannon, Lord Seymour, and Mr. Labouchère, the Commissioners, have been for some time investigating the management of the Post-office, and have made nine reports on the subject. These reports will be for ever useful on account of the minute and accurate information they furnish; but a great proportion of this information, and of the evidence the reports contain, are not calculated to interest the public, and we only purpose to notice that which relates to the cheap and rapid communication of letters suggested by Mr. Hill.

This gentleman, having ascertained from official returns that the total cost of conveying a letter from London to the most remote part of Britain, including the charges for the necessary office establishments, is less than one penny, has been the means of making known to the public, that the chief part of what is paid for postage is in reality a Government tax*.

Mr. Hill discovers that the collection of this tax or postage from house to house is not only very expensive, but materially delays the delivery of the letters; and he quotes the evidence furnished by letter-carriers to the Commissioners of Inquiry; these parties stated that if all letters were paid beforehand, so that no postage was to be collected at the time of delivery, they could deliver, with more ease, and in less time than at present, five times the number of letters.

The payment beforehand at the receiving-houses has met with many objections; these are discussed by Mr. Hill, and to obviate them, he suggests the use of stamped covers, to be issued by the STAMP-OFFICE, and sold by all post-masters and by stationers, which covers should convey the letters free of all postage, and relieve the Post-office from all the difficulty and expense attending the collection.

This is a stepping-stone to the more important measure suggested by Mr. Hill; viz., the charging the public with a much lower rate of postage than they pay at present, and which he alleges would immensely increase the number of letters; and as the delivery of an additional number would not augment the expenses of the Post-office, provided there was no collection of postage, Mr. Hill states, and it appears to us with great reason, that the public might have the opportunity of corresponding at a comparatively trifling expense, without any sacrifice to the revenue.

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* *In his pamphlet on Post-office Reform.*

It is in all cases desirable that any required amount of revenue should be raised at the lowest possible rate of charge; and it has been often experienced, in the Excise and Customs, as it now is in the Post-office, that a high rate of duty produces less revenue than a low rate.

Shopkeepers are well aware that cheapness increases consumption, and, frequently, their own gains at the same time. Every driver of an omnibus knows that he can collect much more money with sixpenny than he could with shilling fares; and as in trade there is no monopoly, they who are able to discover what is most advantageous to the public, take the lead, and compel others to follow. But we never see governments spontaneously conforming to this rational and beneficial principle. It is true there are cases in which they have been driven to lowering the rate of taxation, but it has been almost invariably the result of public excitement, or the urgent persuasion of some powerful interest. However, let the cause be what it may, the effects are always the same; viz., increase of consumption, and, consequently, of commerce or manufactures, and the promotion of individual comfort and public enjoyment.

At the time when Mr. Hill's proposition was submitted to the Commissioners, the branch of inquiry on which they were engaged was the TWOPENNY POST, and they seem to have considered its application to *that* with a very careful study of its probable effects, and with all the fairness and liberality that Mr. Hill could expect. They recommended the adoption of it so far as to allow the public to purchase covers for one penny which should frank letters through the whole district of the twopenny and threepenny post, but leaving still the option of putting in letters unpaid and unfranked, liable to the same rate of charge as at present; viz., twopence or threepence (according to the distance).

As this plan would transfer a great amount of the business from the Post-office to the Stamp-office, the Commissioners examined Mr. Pressly, the secretary of the latter department, upon it. This gentleman thought favourably of the plan, but pointed out the danger of the stamps being forged, to guard against which he suggested the use of a particular paper, invented by Mr. Dickinson, of Hertfordshire; and as Mr. Dickinson himself was examined subsequently, we shall give his description of this very peculiar fabric, of which the Commissioners have issued specimens bound up with their Report.

"The Commissioners understand that you have turned your attention to a mode of fabricating paper which would be applicable for stamps, or any purpose of that kind, and which you suppose it would be very difficult to imitate.——I have.

"Will you have the goodness to describe to the Commissioners what that mode is?——The paper is manufactured with threads of silk, or cotton, or flax, as may be found necessary, in the centre of the sheet. I took the idea from the white strand in the Government cordage, which is introduced for the purpose of distinction, and to prevent thereby the pillage of Government rope. The specimens of paper which you have seen are manufactured by large and complicated machinery, for which I took out a patent; and this paper could not be manufactured in a clandestine way, on account of the nature of the machinery, and because the manufacture of the paper is carried on under the inspection of the Excise.

"You conceive it would be very difficult to manufacture such a paper so as to escape the vigilance of the Excise?——Yes, I am convinced it would; and that, if prohibited by heavy penalties, it is not likely to be attempted; for such paper is difficult to make, and requires space, and a great deal of machinery. The manufacture of paper can only be carried on with a license, and upon premises entered in the Excise-books, and which are surveyed by the Excise-officers. Of course the Excise-regulations are enforced by heavy penalties; and, I presume, that if Government adopted this paper for the protection of any branch or branches of the revenue, they would secure the sole use of it by very stringent legal enactments. Any counterfeit, by sticking sheets together, would have a very different appearance, and the fraud could easily be made manifest in case of an investigation being necessary.

"What do you mean by that?——Supposing that a forgery of this paper were attempted, it could only be by sticking two sheets of paper together with threads between them, by means of glue, gum, paste, or some other adhesive substance. An imitation so produced, would be stiff, clumsy, and altogether of a different texture and appearance, from the genuine paper, and the fraud might be immediately detected by steeping a small portion of the sheet in hot water, which would produce a separation. But supposing the cohesion were effected by means of some cement, not soluble in water, there would still be the palpable difference in the appearance and texture of the sheet, and the fraud would be at once demonstrated by the impossibility of extricating the thread. In my paper, by tearing it in a particular manner, the thread can always be got out clean, but if it were stuck to the paper by any cement, it could not be got away from it, and exhibited in the pure distinct state in which it appears, when detached from all paper manufactured by my process.

"Would it be possible to use threads of different colours in fabricating such paper as you have described?——Threads of any colour might be introduced: and any arrangement of those colours that might be required, and the intervals between the threads might be adjusted to any distance that was wished.

"You have proposed to the Stamp-office to adopt your paper for Government purposes?——Yes, I have recommended this paper for stamps, and other Government purposes, on the ground of its entire novelty and peculiarity, the difficulty of its manufacture, and of counterfeiting it, and its admitting of an easy and definite description. It is an article not required for any general purpose or manufacture, and the prohibition of its fabrication, or of its being in possession of any person, unless with permission of Government, would be no hardship or inconvenience to the public. The possibility of diversifying the colour, arrangement, and material of the threads, renders it capable of endless variety, and suited for numerous important objects, if adopted as a Government paper.

"The Stamp-office have not done so?——They have not yet adopted it.

"Did they make any particular objection to its adoption?——I never heard any objection made to the paper, but on account of the difficulty of making a great change in the whole establishment. Everything that has been said to me upon the subject of the paper, has been consonant to my own views of its fitness for the prevention of forgery."

We would willingly have gone to the expense of supplying specimens to our subscribers of the stamped covers recommended by the Report, but we cannot obtain the sanction of the Commissioners for publishing them. They are printed forms of elegant and elaborate workmanship, stamped on this very curious paper. From some of them we have extricated some of the threads, and find them, exactly as Mr. Dickinson describes, completely in the centre of a sheet of paper of very moderate thickness, but perfectly covered on both sides. They reminded us forcibly of Pope's simile:

Pretty in amber to observe the forms
Of hairs, or straws, or dirt, or grubs, or worms;
The things we know are neither rich nor rare,
But wonder how the devil they got there.

We are aware of Mr. Dickinson's inventions, and of his great manufacturing skill and celebrity; but there are few specimens of practical science which better illustrate the present state of knowledge, the rapid progress of the useful arts, and the triumph of machinery, than this paper. The necessity of preventing the forgery of stamps creates a demand for something entirely novel, remarkable, distinguishable, difficult to make, difficult to imitate; and such is the state of science,—of mechanical skill,—of art generally, that a practical man supplies the thing at once, possessing perfectly all the required qualifications, and produced, as in this case it is desirable it should be, by means of extensive and complicated machinery.

But we ask, is there no practical science in political economy? or, rather, is there not the same connexion of cause and effect in the moral as in the material world? We have experience as certain to guide us in judging of the reasoning of Mr. Hill, as that which enabled Mr. Dickinson to foresee the operation of his machinery, and the results of his manufacturing arrangements. Can our rulers be blind to facts which are apparent in the daily intercourse of man and man, and pervade all the operations of trade and commerce? Is practical science to be brought to bear in all our private transactions, to be operating daily, hourly, with the most stupendous effects, illustrating the means and results of calculation, the power of reasoning from the known to the undiscovered, of carrying forward the most exalted researches, and the most important or the most minute improvements in arts, processes, mechanism, agriculture,—is it to be brought to bear on the human character by education, discipline, association,—and is the Government of the country alone to be impregnable to its influence, insensible of its value, incapable of its exercise? We trust not; and we would suggest to Mr. Hill, that his business is rather with the head of the Government, than with Commissioners, or any subordinate functionaries; we look upon the improvements he suggests, to be of the highest public importance, and that they ought to be at once carried into effect, on the most extensive scale, instead of timidly and unjustly confining the benefit to the metropolis and its immediate neighbourhood. We hope neither Lord Melbourne nor Mr. Rice are so much in the rearward of science, or so subject to old-womanish fears about the Revenue, as to shrink from the scheme of Mr. Hill, so pregnant as it is with advantage to the public.

MISCELLANEA.

Extraordinary Inversion of the Seasons with regard to the Sun.

"A PERPETUAL spring prevails on the plateau of Chuquito, Upper Peru; snow is a rare phenomenon, and yet this fruitful region lies beyond the natural boundaries of trees. Titicaca, the great lake of the country, situated at a height of 12,700 English feet, is traversed by canoes made of rushes at all seasons of the year, and, nevertheless, wheat and rye do not ripen. Maize, which in Europe does not extend to the sub-arctic zone, is not cultivated on the banks of the lake; but, under particular precautions, ripens on the islands in the middle of the lake. This maize was consecrated in former times, and was carried to all parts of the Peruvian empire by virgins dedicated to the worship of the sun. These few facts are sufficient to authorize the observation, that there must prevail on the plateau of Chuquito a climate very peculiar, and widely different from that belonging to the corresponding zones of northern Europe.

"If we compare the vegetation of the district now before us, in regard to its physiognomy, with that of European districts, we shall find that it corresponds to the region of the alpine roses, or to that of shrubs in our mountain vegetation; and that it resembles the vegetation of the most southern portion of the arctic zone in the vegetation of the plains. But the strong contrasts of the seasons, with their great differences of temperature, which occur in the northern zone, and the very equable temperature of the lake of Titicaca, must naturally give rise to very great distinctions in regard to the vegetation of the corresponding regions. The most important circumstance, however, in forming our estimate of the climate of the plateau of Upper Peru, is the remarkable phenomenon, that there, *the winter, that is, the period from May to November, is not only the dry season, but also the warm one; while, in the real summer, according to the position af the sun, that is, from November to April, the wet, and, at the same time, the colder weather prevails.* During the latter hardly a day passes without rain, and falls of hail and snow, which are so very rarely observed, take place in November and December, the very months which ought to be the hottest of the whole year.

"This extraordinary inversion of the usual meteorological relations produced by the position of the sun, is certainly a phenomenon well worthy of attention, not only for meteorology, but also for the physiognomy of vegetation, and the social condition of human society. It is evident that since the winter, according to the position of the sun, is the dry season, the temperature at a particular place, owing to the constant clearness of the heavens, and the consequent opportunity afforded for the increase of heat by means of the sun's rays, must be much higher than could belong to it according to general laws. On the contrary, and this is of the greatest consequence for the vegetation, the summer is so much the colder, because, owing to the constant rains and the evaporation of the fallen water, the refrigeration of the air ensues; and this chiefly because the very foggy atmosphere prevents the passage of the sun's rays. It is also sufficiently well known, that at such great heights on the mountains, whenever the influence of the sun is wanting, a very low temperature is immediately the consequence.

"Thus, then, on the extensive plateau of Upper Peru, the climate is in this remarkable manner altered to the prejudice of the vegetation, and all its dependent relations; and we need not therefore wonder that the height of the snow-line, and that of the highest vegetation in the country, should not rise 2000 feet higher than on the Himalayah range; the difference of the latitude of the two mountain masses indicating exactly this difference in height of 2000 feet."—MEYEN. *Wiegmann's Archiv. für Naturgeschichte.*

Mr. Babbage's New Calculating Engine.

"About October, 1834, I commenced the design of another and far more powerful engine. Many of the contrivances necessary for its performance, have since been discussed and drawn according to various principles; and all of them have been invented in more than one form. I consider them, even in their present state, [April, 1837,] as susceptible of practical execution, but time, thought, and expense, will probably improve them. This new engine will calculate the numerical value of any algebraical function—that, at any period previously fixed upon, or contingent on certain events, it will cease to tabulate that algebraical function, and commence the calculation of a different one, and that these changes may be repeated to any extent.

"The former engine could employ 120 figures in its calculations: the present is intended to compute with about 4,000."—Babbage. *Ninth Bridgewater Treatise.*

Estimate of Solar Heat annually received by the Earth.

"The surface of the globe being four times the area of a section of the sunbeam constantly incident on it, and the quantity of heat continually received by the earth (or, at least, into its atmosphere) being necessarily greater than the maximum *ever* observable at its surface, it follows from this that the solar heat annually incident on our globe would suffice to melt, *at least*, 84·54 feet of ice over its whole surface. Perhaps 100 feet would be nearer the truth; the radiation here assumed as an example, being by no means the greatest I have observed at the Cape. The clouds, however, probably radiate off a large proportion of this heat as soon as received, and prevent its ever reaching the ground."—Herschel, Sir J.

Ecstacy of Discovery.

Prof. Leslie, "early in the summer of 1810, determined to proceed with a set of experiments previously suggested in the course of his researches with his hygrometer, but which had for some time been suspended; and they now, on being resumed, conducted him to the discovery of that beautiful process of Artificial Congelation, by which he was enabled to produce ice, and even to freeze mercury, at pleasure. The discovery was achieved by means of a happily conceived combination of the powers of rarefaction and absorption, effected by placing a very strong absorbent under the receiver of an air-pump. It was in the month of June of that season that the discovery was consummated. We happened to witness this consummation,—at least, the performance of the first successful repetition of the process,—and we never shall forget the joy and elation which beamed on the face of the discoverer, as, with his characteristic good nature, he patiently explained its principles, and the steps by which he had been led to it*. We could not but feel, on looking at, and listening to, him, how noble and elevating must be the satisfaction derived from thus acquiring a mastery over the powers of Nature, and enabling man, weak and finite as he is, to reproduce at pleasure her wondrous works!"—Napier. *Memoir of Leslie.*

Dangerous Error in Sir H. Davy's Bakerian Lecture. 1826.

In a communication, by Mr. A. Van Beek, to the thirty-eighth volume of the *Annales de Chimie et de Physique*, there is a note annexed, of the following purport:—"In the course of my experiments upon the preservation of metals, I discovered a serious error, committed by the celebrated English chemist, Sir Humphry Davy, in the Bakerian Lecture of the 8th of June, 1826, 'on the Relation of Electrical and Chemical Changes,' published in the *Philosophical Transactions*, 1826. In this paper he recommends the use of zinc or

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* The successive steps of the discovery are recited by himself in the article Cold, in the *Encyclopædia Britannica*, in those *verba ardentia* which the bent of his genius so strongly prompted him to employ.

tin for the preservation of steam-boilers, particularly in those of steam-boats, where sea-water is frequently employed. Some decisive experiments have convinced me that tin is so far from preserving iron, that, on the contrary, it is preserved by the latter metal: and therefore a piece of tin introduced into the boiler, instead of preserving the iron from oxidation, and by this means diminishing the danger of explosion, must powerfully contribute to its rapid corrosion. Zinc alone should be employed in those cases where it is intended to take advantage of the useful principle of the reciprocal preservation of metals."

Dr. John Davy, in the *Edinb. Philos. Journ. April—July*, 1834, endeavours to vindicate the opinion of his deceased brother, and to show that Mr. Van Beek was in error. This had the effect of inducing Mr. Van Beek to re-examine, with the utmost care and impartiality, the whole question, and to publish whatever might be the result of the investigation.

The experiments of Mr. Van Beek are described minutely and clearly, in the *Edinb. Philos. Journ., pub.* 1 *July*, last, to which work we must refer for them.

The result is a confirmation of Sir H. Davy's error; and by the sagacity of a third party, Mr. G. T. Mulder, of Rotterdam, the detection of the oversight which vitiated the whole train of the reasoning of Dr. John Davy.

The latter had stated that "his galvanometrical experiments always showed him tin as positive in its electrical relation to iron, and that, therefore, iron must be defended by tin."

Mr. Van Beek observes, that "owing to the want of a good galvanometer, I was not able, in the course of my former experiments, to make these inquiries, and I was now therefore anxious to determine the point to which I have just alluded.

"I must confess that, at first, to my great surprise, I found the fact as Dr. Davy states, observing the astatic needles of the galvanometer, by the immersion of iron and tin in sea-water, to show immediately a deviation corresponding with a positive electrical relation of tin to iron.

"It was principally the sagacity of my friend Mr. G. T. Mulder, of Rotterdam, which made me notice, that, by prolonging the experiment during a certain time, the needles always return to zero, and afterwards show an opposite deviation, the tin acquiring a negative electrical relation to iron.

"The galvanometrical researches have taught us, as a constant law, that where two metals are immersed together in a fluid, the metal that suffers the strongest oxidation is always positive in its electrical relation to the other less oxidated metal. Yet, where tin and iron or steel are both placed in atmospherical air, the tin is, without any doubt, positive in respect to the iron; for both metals being perfectly polished and bright, the tin is almost directly tarnished, and its surface becomes covered with a thin layer of the oxide of tin, whilst the steel remains still perfectly bright. Now, it is a curious circumstance, that this electrical relation of the two metals, acquired in the atmospherical air, subsists during a certain time after their immersion in sea-water, in consequence of a singular property; and it thus appears, that metals retain, for a longer or shorter time, the electrical state once acquired. I discovered this interesting fact, by making experiments on the preservation of copper by iron in sea-water, and it forms the contents of my memoir containing the note under discussion*.

"Very soon, however, the needles of the galvanometer, after having returned to zero, show an opposite deviation, and thus prove evidently, that the electrical relation of the two metals is wholly changed. The iron being more strongly oxidated than tin in sea-water, becomes positive in respect to this metal; and this positive electrical relation of the iron remains and increases by the increasing oxidation of this metal in sea-water.

"The time during which tin preserves its positive electrical relation to iron acquired in common air after the immersion in sea-water, depends on the quality of the iron, and, perhaps, still more on the condition of its surface, and the temperature of the sea-water. In general, the brightest surface of iron retains the longest its primitive electrical state, resisting powerfully the stronger oxidation which it must soon undergo in sea-water.

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* "Prof. A. de la Rive has discovered a similar property of the metals by a different process."

"Generally, this phenomenon lasts only for a few minutes. I have seen it once continue during about half an hour, when making the experiment with bright polished steel, by a mean temperature.

"The chemical purity of tin seems not to have any influence on these experiments.

"It appears evident, that Dr. John Davy, by his galvanometrical experiments, attended, as I did myself at first, only to the direction of the needles soon after the immersion of the metals in sea-water, neglecting to extend the experiment during a certain time, otherwise he would doubtless have remarked the opposite deviation of the needles.

"As to me, I am now perfectly convinced of the fact, that tin cannot be made use of with success, to protect iron from corrosion in sea-water; tin, on the contrary, being in that case protected by iron; and I invite all philosophers to repeat my experiments, and so convince themselves of what I have advanced."

Prof. Edm. Davy, of Dublin, and Mr. G. T. Mulder, of Rotterdam, had anticipated this invitation, and made experiments which confirmed the statements of Mr. Van Beek.

"*Saddle-Iron.*"

Pig-iron has its name from a fancied resemblance to a sow and pigs, which is given to the metal on running it into the sand. There is no doubt but the form was selected for its convenience. A Turkish iron-master in Romelia, from the same motive, has adopted one which his brethren in this country of facilities would be long in seeing the propriety of, namely, that of a saddle. "At 1½ league to the east of Egri-Palanka in Romelia, we visited some very picturesque *cavages*, established for procuring the octahedral iron-ore, which is disseminated in almost imperceptible crystals in a decomposed state. A stream of water is made to fall upon the rocks, to enable the workmen to separate the iron; and the smelting of it is not less curious; the kiln is opened every sixteen hours, and an immense quantity of charcoal is consumed. *The iron is cast in the form of a saddle, that it may be more easily transported on asses.* These mines afforded a great quantity of iron, which would be of good quality if it were properly treated."—Boué. *Geology of Turkey.*

Plant Skeletons—A new Class of Subjects for the Microscope.

"The existence of a skeleton in every plant may be demonstrated by burning the latter at a candle, and afterwards placing it carefully under the microscope. It will be easy to recognise the original structure of the plant before it falls to pieces*. This is also with extremely thin carbonized sections. Thus, for example, the spiral vessels of the *Taxas* can be observed without difficulty. It would appear, that it is owing to the want of proper precautions that we cannot always discover the vegetable structure in coal.

"On heating a specimen of fossil fern, there remained behind a skeleton, composed of potash, similar, according to my observations, to the skeletons left by recent ferns, in which, indeed, the jointed rings of the sporangia are also similarly constructed. A drop of water destroys the whole structure, and dissolves everything except an exceedingly minute residue of silica.

"These facts are of importance in a geological point of view, as they prove decisively that this fern, neither before, after, nor during its envelopement in the clay, could possibly have been exposed to a long-continued aqueous action; for had such been the case, no trace of so very soluble a salt as potash would have remained. The investigations of Karsten prove that water, when it acts during the formation of coal, produces this effect; for he found that the ashes of fossil wood and of brown coal contained no trace of fixed alkali."—GÖPPERT. *Poggendorff's Annalen.*

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* "Skeletons so prepared are composed of potash. Struve, in his memoir *De Silica in plantes nonnulles, Berol.* 1835, treats *of the siliceous* skeleton of plants, and I had ample opportunity of confirming his results. Several plants, as the *Chara*, yield a *calcareous* skeleton."

Enormous Cutaneous Absorption.

"THE importance of cutaneous absorption, both in fishes and reptiles, has been demonstrated by the experiments of Dr. Edwards. The human body, in certain states both of health and disease, is also greatly dependent upon it. A curious instance of the extent to which it may take place from atmospheric moisture alone, was related to me a few years ago whilst in the West Indies, by the governor of the island in which I was residing. A jockey, who had been in training for a particular race, being much depressed by thirst, on the morning on which he was to ride, drank a single cup of tea; the stimulus to the cutaneous system was so great, that he increased in weight 6lbs., of which 5lbs. must have been from atmospheric moisture."—CARPENTER. *Jameson's Journ.*

Elevation of Beaches by Tides.

"IF the earth were a spheroid of revolution, covered by one uniform ocean, two great tidal waves would follow each other round the globe at a distance of twelve hours.

"Suppose several high narrow stripes of land were now to encircle the globe passing through the opposite poles, and dividing the earth's surface into several great unequal oceans, a separate tide would be raised in each. When the tidal wave had reached the farthest shore of one of them, conceive the causes that produce it to cease: then the wave thus raised would recede to the opposite shore, and continue to oscillate until destroyed by the friction of its bed. But if, instead of ceasing to act, the causes which produce the tide were to reappear at the opposite shore of the ocean, at the very moment when the reflected tide had returned to the place of its origin; then the second tide would act in augmentation of the first, and, if this continued, tides of great height might be produced for ages. The result might be, that the narrow ridge dividing the adjacent oceans would be broken through, and the tidal wave traverse a broader tract than in the former ocean. Let us imagine the new ocean to be just so much broader than the old, that the reflected tide would return to the origin of the tidal movement half a tide later than before; then, instead of two superimposed tides, we should have a tide arising from the subtraction of one from the other. The alterations of the height of the tides on shores so circumstanced, might be very small, and this might again continue for ages; thus, causing beaches to be raised at very different elevations, without any real alteration in the level either of the sea or land.

"If we consider the superposition of derivative tides, similar effects might be found to result; and it deserves inquiry, whether it may not be possible to account for some remarkable and well-attested phenomena by such means.

"The gradual elevation, during the past century, of one portion of the Swedish coast above the Baltic, is a recognised fact, and has lately been verified by Mr. Lyell*. It is not probable, from the form and position of that sea, that two tides should reach it distant by exactly half the interval of a tide, and thus produce a very small tide; nor is it likely that, by the gradual but slow erosion of the longer channel, one tide should almost imperceptibly advance upon the other; but it becomes an interesting question to examine whether, in other places, under such peculiar circumstances, it might not be possible that a series of observations of the heights of tides at two distant periods might give a different position for the mean level of the sea at places so situated.

"If we conceive two tides to meet at any point, one of which is twelve hours later than the other, the elevation of the waters will arise from the joint influence of both. Let us suppose, that, from the abrasion of the channel, the latter tide arrives each time one-hundredth of a second earlier than before. After about 3150 years, the high-water of the earlier tide will coincide in point of time with the low water of the latter tide; and the difference of height between high and low water will be equal to the difference of the height of the two tides, instead of to their sum, as it was at the first epoch.

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* "See *Phil. Trans.* 1836."

"If, in such circumstances, the two tides were nearly equal in magnitude, it might happen that on a coast so circumstanced, there would, at one time, be scarcely any perceptible tide; and yet, 3000 years after, the tide might rise thirty or forty feet, or even higher; and this would happen without any change of relative height in the land and water during the intervening time. Possibly this view of the effects which may arise, either from the wearing down of channels, or the filling up of seas through which tides pass, may be applied to explain some of the phenomena of raised beaches, which are of frequent occurrence[*]."—BABBAGE. *A Ninth Bridgewater Treatise.*

Science assisted by the State.

WE have the pleasure of recording the following boon to science, mentioned incidentally by M. Arago, in the *Académie des Sciences*, on the 15th May last.

The Neapolitan Government has furnished the New Observatory at Capo de Monte in a magnificent manner, and still more recently has commissioned Sig. Cappocci, the Director of the Observatory at Naples, to enrich the scientific institutions of this city with instruments of every kind; the best that can be produced in France, England, and Germany.

Damming of the Nile.

THE great work of damming the Nile, so long contemplated by the enterprising Pasha of Egypt, but which had been suspended, is reported to be about to be recommenced, under the directions of M. Linant, a French engineer. An extract from the diary of an intelligent traveller, who has kindly put it in our hands for the purpose, will present a clear idea of the intention of the work, and of the mode of executing the preliminary works.

"*3d Dec.* 1834.—To-day we came to the Barrage[†]. I called at the house of Le Pere Enfantin[‡], but found that he was at Cairo. We got a fellow who had an immense thong in his hand to show us about. He was a Frenchman. The object of this work is, to command the Nile at low water so as to flood the upper country, and to direct the Nile's course out of the two present channels, which lead down to Rosetta and Damietta, into one middle one, which is to be carried through the centre of the Delta, which is to be somewhere about eighty miles long. I am informed that the work is to extend about five English miles; that the Nile is nearly three miles broad at this point when at high water; and that its current *is then* somewhere about five miles an hour.

"There are 6000 men employed here, and 7000 on the Damietta side, making together 13,000 in the whole: the works are about three miles from the south *point* of the Delta, and are consequently on dry land. The men have been engaged about seven months: they are making excavations for the foundations of a series of arches, the centre one of which is to be 111 feet 7 inches in span; the smaller ones are only to be 26 feet 3 inches. No great works, however, are yet visible, the whole being merely an excavation. I hear that there is to be a canal with locks, to admit the boats to get into the old channels of the Nile below the embankment. Our guide is a sad ignorant fellow. He tells us the men are all pressed into the service, and that they will not work without flogging; and of this department he is the chief. The men's wages are thirty paras, [there are forty paras to a piaster, which is equal to about 2½*d.* of our money,] and four little cakes per day: the boys' wages are twenty paras, and the *same* number of cakes. These cakes are about the size of a *twopenny bun.* The men will not use the spade or shovels, but work entirely by hand; the soil, however, is quite soft, being as yet altogether a deposit of the Nile. The Sacchias (or Persian wheels) are worked by men as in a tread-mill. We saw three stables for 400 bullocks *each*, which were beautifully clean: only one, however, was occupied, and that only partially, the rest were not quite complete. There are joiners' and smiths' shops on the premises, as also limekilns; the latter supplied by Newcastle coal. There is also a large bakehouse on the premises, where the small cakes are made for the workmen. It is a curious scene. On one side of it were three stone cisterns full of flour and water, and in the midst of this, were jumping and rolling about three naked men, in order to effect its conversion into paste. In another corner were men weighing and dividing the paste into cakes. We tasted the cakes, and found them excellent. I hear Mr. Galloway* considers that this undertaking is a very injudicious one, and that Boulac (the port of Cairo) will be destroyed if it be continued."

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[*] "The great temporary floods which have occasioned the deposition of the remains of the ocean, considerably above the level of sea, such as the great flood described by Boethius, which, he says, 'happened in the Ides of October, in the year *of Redemption 1097,* carrying destruction into the country, overwhelming villages, castles, towns, and extensive woods,' may explain some of these raised beaches."—EDIT. *Jameson's Journal.*

[†] The French term for a river-dam.

[‡] Once the leader of the sect of the St. Simonians.

Remarkable Spots on the Sun, in March 1837.

THE following note was made by Sir John Herschel, at Feldhausen, near Wynberg, at the Cape of Good Hope, during the Spring-equinox of the present year.

"The sun at present is, and has long been, affected with a display of spots, extraordinary both in point of number and magnitude, and in every point of view extremely remarkable. They do not, however, appear to have affected its emission of heat; at least, I perceive no marked excess or defect of radiation, as indicated by the Actinometer, this year, compared with corresponding seasons of 1834, 1835, and 1836. This instrument puts all such inquiries completely within our power."

Consolation to the Dull.

MR. NAPIER, in his narrative of the endeavours that were exhibited to transfer the merit of the discovery of the process of Artificial Congelation from Professor Leslie to Mr. Nairne, gives a fact and note, which may be of some solace to those, who, from deficiency of self-esteem, (to use the language of phrenologists,) are apt to pass many a bitter moment in useless self-reproach; attempting nothing, because discontented with the means nature has allotted to them, and believing that others can see without effort, and intuitively, into truths which to them are sealed mysteries. Here they will find, that Sir Humphrey Davy once tried, "but without success," and that the whole philosophic world of London, with all the facts before them, were at fault, until Mr. Leslie arrived to show them the way to perform an experiment, now regarded as one of the easiest in the laboratory.

"Perhaps," says Mr. Napier, "there is not in the whole history of science, any more triumphant reply to a charge of plagiarism, than is furnished by the admitted facts, that, with Mr. Nairne's paper before it for a long course of years, the scientific world remained utterly ignorant of the existence of any such process till the date of Mr. Leslie's discovery;—nay, that with his description of that process in their hands, the most distinguished experimentalists of the capital failed in their trials of it, till it was performed there by himself, in the ensuing Summer.

"In a letter from London to one of his friends, written in June, 1811, he says,—'My package has at last arrived, and I shall proceed without delay to make my *debut.*' It was only now that the experiment was first successfully performed in the capital. This took place in presence of several members of the Royal Society.

"Some curious legal evidence of these facts was adduced by Professor Leslie, in 1822, in a prosecution which he was advised to institute against the publisher of a well-known 'Magazine,' for a series of libels inserted in that work;

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* An English engineer, patronised by the Pacha, and long resident in Egypt. He is since dead.

in one of which he was accused of having stolen the discovery alluded to from Mr. Nairne. Amongst other witnesses, two very distinguished chemists were examined on that occasion—the late Dr. Marcet, and Dr. Thomson, Professor of Chemistry in the University of Glasgow. The evidence of both was equally favourable to Professor Leslie. We shall extract a small portion of that of Dr. Marcet, to whom the Professor was personally but little known :—' Q. Is it your opinion that Mr. Leslie is to be considered as having borrowed or stolen this discovery, or do you consider his discovery to be original?—*A*. Some of the facts were known long before, but the process itself is perfectly original.—Q. Is the discovery of Mr. Leslie analogous to other discoveries in the science of chemistry?—*A*. There is hardly any discovery of the least value that has been made in that science, but from the known properties of bodies. It is by combining those properties, so as to produce certain effects, that a discovery is made.—Q. Then you mean to say that Mr. Leslie has done what none before him ever accomplished?—*A*. Certainly. *He has done what the whole philosophic world, with all the facts before them for a long period, had not been able to accomplish.*—Q. When and by whom was the experiment first successfully performed in London?—*A*. It was successfully performed in London by Mr. Leslie himself. My belief is, that no one succeeded in this experiment in London, until Mr. Leslie himself showed the way.—Q. Do you know that Sir Humphrey Davy tried and failed?—*A*. I cannot positively say: I believe he tried it, but without success." — (*Report of the Trial by Jury, Professor Leslie against William Blackwood*, p. 82-6.)

Turkish Encouragement of Mining!

"FEW metalliferous deposits are *known* in Turkey. Neither Turks nor Christians like to expose mines, as they are afraid of being obliged to work them." —BOUÉ. *Geology of Turkey.*

The Calculating Engine.

THE following "brief account of the Progress and Present State of the Calculating Engine," was published by Mr. Babbage, in a late work, the Preface of which is dated 16th April, 1837.

"About the year 1831, I undertook to superintend for the Government, the construction of an engine for calculating and printing mathematical and astronomical tables. Early in the year 1833, a small portion of the machine was put together, and it performed its work with all the precision which had been anticipated. At that period circumstances, which I could not control, caused what I then considered a temporary suspension of its progress; and the Government, on whose decision the continuance or discontinuance of the work depended, have not yet communicated to me their wishes on the question.

"Here I should willingly have left the subject; but the public having erroneously imagined, that the sums of money paid to the workmen for the construction of the engine, were the remuneration of my own services for inventing and directing its progress; and a Committee of the House of Commons having incidentally led the public to believe, that a sum of money was voted to me for that purpose, I think it right to give to that report the most direct and unequivocal contradiction."—BABBAGE. *Appendix to "The Ninth Bridgewater Treatise."*

Third Irruption of the River into the Thames Tunnel.

WE regret that we have to lay before the world the following letter from the Clerk of the Thames Tunnel Company:—

"Sir,—Knowing the very great interest which the public have always felt in the progress of the Thames Tunnel, I have taken upon myself to address you, in order that they may at once be in possession of an authentic statement of the circumstances which have occurred this afternoon at these works.

"At a little before twelve o'clock this morning the water was found to increase considerably; but in the course of the afternoon the quantity had somewhat diminished, although it still slowly gained upon the pumps; and, as the tide rose, it was found quite impossible to keep pace with the increased influx of water, when Mr. Page, the acting engineer, considered it necessary to send for Mr. Brunel, who was in town attending at a meeting of the board of directors.

“ At five o'clock, finding it was quite useless to proceed in the attempts to check the steady increase of the water, which had then risen to ten feet, the attention of the engineers and the workmen was therefore turned to securing all parts of the shield, which operation was carefully and deliberately done.

“ The curiosity of the men, who were anxious to watch the gradual rise of the water, rendered it very difficult for the engineer to withdraw them even when it had become expedient to do so.

“ By about half-past five the tunnel was filled, everybody having retired in good order.

“ It is gratifying to add that no accident has occurred to any individual.

“ Soundings were immediately taken by the engineers, and the displacement of ground having been ascertained to be of limited extent, steps were taken forthwith to stop the aperture from above, as on former occasions, in order to resume the pumping as soon as possible.

“ I remain, sir, your obedient servant,
“ J. Charlier,
“ Clerk to the Company.”

“ *Thames Tunnel Works, Rotherhithe,*
Wednesday, 9 P.M., *Aug.* 23, 1837.”

Locomotives on Towing-Paths.

An experiment, strongly marking the onward spirit of our countrymen, was made on a Scotch canal, in the latter part of the month which has just expired. Mr. T. Graham, the great patron of rapid travelling by canals, has induced a canal-company of which he is a member, to attempt the substitution of a locomotive engine for the horses by which their rapid boats were drawn. The experiment was made under the direction and personal superintendence of Mr. Macneill, the civil engineer. The result was of the most promising kind. The boats were drawn eight to ten miles under very unfavourable circumstances, and it was the opinion of several experienced practical men present, that there appeared no reason why eighteen miles should not be accomplished, when a little more practice has familiarized the apparatus, and the roads, &c., should be properly prepared to receive it.

Family of Philosophical Instruments.

“ After leaving Etruria, he [Leslie] passed some months in Holland. . . . . Thereafter, he returned to Largo, where he remained for about two years devoted to experimental researches; in the course of which, [in the winter of 1794—5] he invented and perfected his Differential Thermometer, the parent, if we may so speak, of that beautiful Family of Philosophical Instruments*, with which he enriched the Treasury of Science, and amplified and variegated the means of physical inquiry. His ingenuity had been early exercised in some attempts to construct an accurate Hygrometer, and these ultimately suggested to him the well-known contrivance above named;—a contrivance happily adapted to the measurement of the smallest variations of temperature, and which richly rewarded his inventive powers by its ministry to the achievement of his subsequent discoveries. It has generally, indeed, been allowed to be one of the most useful, as well as elegant inventions, that inductive genius ever applied to the investigation of chemical changes.”—Napier. *Memoir of Leslie.*

* “ These Instruments, viz. the Differential Thermometer, Hygrometer, Hygroscope, Photometer, Hyroscope, Æthrioscope, and Actinometer, are all described, and their principles explained, by himself, in the articles “ Climate,” and “ Meteorology,” in the *Encyclopædia* [*Britannica*]. Properly speaking, the Hygrometer was the *parent* instrument; the Differential Thermometer having been invented in the course of his endeavours to improve it; but as the Hygrometer, in its latest form, is only a modification of the other, it may be represented as derived from it.”

Association of Full Moon and Cloudless Sky.

" THE association of full moon with a cloudless, or nearly cloudless, sky, has often suggested itself as a point of Meteorology worthy of some inquiry."—HERSCHEL, SIR J.

Organic Life not simultaneously extinct with Animal Life.

" IT is a curious fact, that after *animal* life is extinct, a certain degree of *organic* life frequently remains, by which the excretory functions go on for a time thus carbon is exhaled in considerable quantity from the skin for a certain period after death: perspiration has appeared on the skin, urine has been secreted into the bladder, and it is even said that the hair has grown. It is only when these excretions are finally stopped by the want of circulation, respiration, and other vital functions, that decomposition can be properly said to commence."—CARPENTER. *Jameson's Journ.*

Important Succedanea.

THE following startling speculation occurs in a paper by Mr. Carpenter, entituled, *An Unity of Function in Organised Beings.* Mr. C. has been advocating the law, that, " A special function arises out one more general, and this by a general change." After stating, that in tracing the gradual development of the functions peculiar to animals, namely sensation and voluntary motion, he conceives the special type may be found to be evolved from one more general, and that the organs of sensation in the ascending scale of animals afford illustrations of the same general principle; he adds, " We may perceive that the special functions of sight, hearing, and smell, are rather elaborated out of the general sense of touch, than superadded to it; and there would not appear, *à priori*, any physiological impossibility in the fifth pair supplying a certain power of sight when the optic nerve is absent, as in the mole; and if the phenomena of the transference of sensation should ever be indisputably established, their explanation on the same principles will be easy."

Patent-Law Grievance. No. XVIII.

THE inventors of this country, and the introducers of inventions of other countries into this, were obliged to pay down to the attorney-general and other agents, &c., of the Government, during the ten years ending December, 1834, more than £313,000, and during the past year above £42,000 (being at the rate of £420,000 in ten years.) It is to be observed that these enormous extortions are *exclusive* of the drawings, engrossings, and all the other charges of the patent-solicitor.

The penalties inflicted on the inventive genius of Britain during the *present* year, up to the 25th ult., in the shape of government stamps and fees on patents, amount to more than £29,000!

N.B. This sum has been paid in *ready money* on taking the first steps, and as many of the inventors are poor men, (*Operatives,*) and a great many others of them persons to whom it would be very inconvenient to pay at least £100 down, they have been obliged to go into debt, or mortgage or dispose of their inventions, either wholly or in part, &c.

NEW PATENTS. 1837.

N. B.—The first Date annexed to each Patent, is that on which it was sealed and granted; the second, that on or before which the Specification must be delivered and enrolled.——The abbreviation *For. Comm.*, signifies that the invention &c., is "a communication from a foreigner residing abroad."

July *contd.*

141. Joseph Henry Inch, of the Rainbow Coffee-House, *Lond.*; for improvements in apparatus or machinery for making or manufacturing candles. July 25.—Jan. 25.

142. John Melling, Liverpool, *Lanc.*, Engineer; for improvements in locomotive steam-engines to be used upon railways; parts of which improvements are applicable to stationary steam-engines, and to machinery in general. July 26.—Jan. 26.

143. William Palmer, Sutton-street, Clerkenwell, *Middx.*, Manufacturer; for improvements in printing paper-hangings. July 29.—Jan. 29.

Total, July...14.

August.

144. James Matley, Paris, and Manchester, *Lanc.*, Gent.; for a machine, called a tiering machine, upon a new principle; for supplying colours to, and be used by, block-printers, in the printing of cotton, linen, and woollen-cloths, silks, paper, and other substances and articles to which block-printing is, or may be, applied, without the aid or assistance of a person to tier upon. Aug. 2.—Oct. 2.

145. Archibald Richard Francis Rosser, New Boswell-court, *Middx.*, Esq.; for improvements in preparing manure, and in the cultivation of land. Aug. 2.—Feb. 2. *For. Comm.*

146. Alexander Macewan, Grocer and Tea-Merchant, Glasgow; for a process for the improvement of teas as ordinarily imported. Aug. 5.—Feb. 5.

147. Richard Thomas Beck, Little Stonham, *Suffolk*, Gent.; for new or improved apparatus or mechanism for obtaining power and motion to be used as a mechanical agent generally, which he intended to denominate *Rotæ Vivæ*. Aug. 9.—Feb. 9. *For. Comm.*

148. William Gossage, Stoke-Prior, *Worc.*, Manufacturing Chemist; for certain improvements in the processes or operations connected with the manufacture of alkali from common salt, and with the use of the products obtained therefrom. Aug. 17.—Feb. 17.

149. William Gilman, Bethnal Green, *Middx.*, Engineer; for an improvement or improvements in steam-boilers, and in engines to be actuated by steam or other power. Aug. 17.—Feb. 17.

150. Henry Shuttleworth, Market-Harborough, *Leic.*, Gent., and Daniel Foot Tayler, Woodchester, *Glouc.*, Pin Manufacturer; for certain combinations of and improvements in machinery for making pins; (an invention of Lemuel Wellman Wright;) *extended five years* from May 15, 1838.

151. John George Hartley, Beaumont-row, Mile-end-road, *Middx.*, Esq.; for an improved application of levers for the purpose of multiplying power. Aug. 22.—Feb. 22.

152. Thomas Du Boulay, Sandgate, *Kent*, Esq., and John Joseph Charles Sheridan, Lewisham, Esq.; for improvements in drying and screening malt. Aug. 24.—Feb. 24.

153. James Crellier, Liverpool, *Lanc.*, and James Holt, of the same place, Plumbers; for certain improvements in water-closets. Aug. 24.—Feb. 24.

154. William Hearn, Southampton-street, Pentonville, *Middx.*, Engineer, and William Davies, Upper North-place, Gray's-Inn-road, *Middx.*, Plumber; for a certain improvement or improvements in the construction of boilers for the generation of steam, and heating water and other fluids. Aug. 24.—Feb. 24.

155. Robert Brown, Waterside, Maidstone, *Kent*, Engineer and Iron-Founder; for certain improvements in the construction of cockles, stoves, or apparatus, for drying or stoving hops, malt, grain, or seeds. Aug. 24.—Feb. 24.

156. William Southwell, Winchester-row, New-road, *Middx.*, Piano-Forte Maker; for a certain improvement in piano-fortes. Aug. 24.—Feb. 24.

METEOROLOGICAL JOURNAL FOR JULY, 1837; KEPT AT BLACKHEATH ROAD.

Day of Month		Barom. 9 A.M.	Ther. attch.	Barom. 3 P.M.	Ther attch	Thermometer. Min.	Thermometer. Max.	Daily Temp	Solar Var.	Rad.	Clouds. A.M.	Clouds. P.M	Winds A.M.	Winds P.M	Direction of Wind A.M.	Direction of Wind P.M.	Lunation.	WEATHER, &c.
Satur.	1	30·362	68°	30·351	68°	46°2	62°0	54°1	15°8	44	5	3	3	2	ENE	ENE		Windy; flying clouds. Night cold.
SUN.	2	30·350	66	30·275	67	41·8	70·2	56·0	28·4	40	0	0	1	1	NE	NE	●	Cloudless.
Mon.	3	30·261	67	30·190	70	47·9	74·0	60·9	26·1	45	3	3	1	2	N	NE.S		Fine, but hazy.
Tues.	4	30·178	69	30·157	70	51·0	71·8	61·4	20·8	49	7	6	1	2	NW	NE		Do., much haze; air parching and dry.
Wed.	5	30·205	69	30·150	71	51·5	73·6	62·6	22·1	50	6	10	0	1	N	NW		Much overcast. *Cumuli, cum-stratus.* Light rain at [sunset.
Thurs.	6	30·178	70	30·180	71	58·0	72·4	65·2	14·4	56	7	8	1	2	N	NE		Cloudy. Night clear.
Friday,	7	30·296	70	30·281	70	51·0	71·0	61·0	20·0	50	8	7	2	2	N	NE		Morn overcast; flying clouds; lightning to N.E., at [11 P.M.
Satur.	8	30·202	69	30·172	72	51·9	76·2	64·1	24·3	51	3	1	1	3	Nly	ENE		Clear. *Cumuli.*
SUN.	9	30·191	69	30·115	69	47·8	63·8	55·8	16·0	46	5	5	2	2	ENE	E		Do. Thin *cumuli.*
Mon.	10	30·005	66	29·976	69	47·1	70·0	58·5	22·9	46	3	2	2	2	ENE	E	☽	Fine. *Cirri* in *patches.*
Tues.	11	30·005	66	29·994	69	48·0	69·9	59·0	21·9	46	3	3	2	2	E	E		Do. *Cirri* and *cirro-cumuli* at sunset.
Wed.	12	29·997	66	29·956	68	54·8	66·0	60·4	11·2	54	9	9	1	1	E	S		Cloudy, with haziness.
Thurs.	13	29·850	67	29·837	69	53·2	73·4	63·2	20·2	50	8	5	1	1	SSW	SW		Do.; fine, P.M.; clouds gather at sunset.
Friday,	14	29·815	67	29·826	69	55·0	73·5	64·3	18·5	53	8	5	1	2	SW	W		*Nimbi*, with showers. Thunder to N.E.
Satur.	15	29·924	68	29·905	69	56·2	72·4	64·3	16·2	53	8	9	2	2	SW	W		Do.; rain fell for two or three hours P.M.
SUN.	16	30·016	69	30·025	70	51·1	70·0	60·6	18·9	49	6	7	3	3	W	W		Wild windy weather, with showers; *thunder* at dist.
Mon.	17	30·058	68	30·019	69	51·5	70·2	60·8	18·7	49	3	9	2	2	W	WSW	○	Very fine, A.M. Clouds collect from W., with showers.
Tues.	18	29·900	69	29·860	70	55·6	72·4	64·0	16·8	55	7	9	1	2	SW	SW		Rain at 6 A.M. Fine, partly cloudy.
Wed.	19	29·885	69	29·840	70	56·4	72·5	64·4	16·1	52	7	6	2	2	WSW	SW		Clouds gathering; rain at sunset.
Thurs.	20	29·926	69	29·944	70	54·2	67·8	61·0	13·6	52	4	10	2	3·2	NW	WNW		Squally. *Cirro-stratus. Cum-stratus* and *nimbus.*
Friday,	21	30·056	69	30·058	70	52·1	68·0	61·0	15·9	50	7	4	2	2	N	N		Fine. Cold for the season.
Satur.	22	30·106	69	30·090	70	52·5	73·8	63·1	21·3	50	5	5	1	0	E	S		Hazy and calm.
SUN.	23	30·066	70	30·039	73	52·6	80·6	66·4	28·5	51	3	9	2	2	W	WNW		*Cumuli* P.M. Close and cloudy. Shower at 9 P.M.
Mon.	24	30·158	72	30·154	72	56·0	73·5	64·8	17·5	54	5	4	1	1	N	N	☾	Fine.
Tues.	25	30·150	71	30·142	72	58·4	74·0	66·2	15·6	55	3	9	1	0	N	sly		Do.; P.M. cloudy. Warm night.
Wed.	26	30·116	71	30·007	73	62·0	79·0	70·5	17·0	60	8	8	2	2	WSW	WSW		Do., *Cirro-stratus* into *Cirro-cumuli.*
Thurs.	27	30·041	72	29·941	76	50·5	81·8	66·2	31·3	49	3	3	2	3	SSW	SSW		Do., *Cumuli.*
Friday,	28	29·825	73	29·824	76	62·2	76·0	69·1	13·8	60	8	4	2	2	W	SW		A shower at 11 A.M. Clear afternoon.
Satur.	29	29·392	73	29·304	74	57·5	68·8	63·1	11·3	57	7	5	4	5	SW	SW.W		Rain early. A violent gale till midnight.
SUN.	30	29·600	69	29·662	70	54·0	68·7	61·4	14·7	53	8	8	2	1	W	W		Cloudy. *Cumulo-stratus.* Thunder showers.
Mon.	31	29·942	68	29·915	69	48·2	72·0	60·1	23·8	46	5	7	1	2	W	WSW		*Cumuli* into *Nimbi*, with showers. Cloudy night.
Mean		30·034	69	30·009	71	52·77	71·91	62·34	19·14									

Bar. Max. 30·362 in. on the 1st.
Bar. Min. 29·272 in. „ 29th.

Ther. Max. 81·8° on the 27th.
Ther. Min. 41·8° „ 2nd.

Lowest point of Rad. 40°, on the 2nd.
Rain fallen (by Crossley's self-registering gauge), 1·610 in.

THE VERNIER.

In our article on the barometer, and at the bottom of the 416th page, we stated that the scale attached to barometers is graduated into tenths of an inch, and that, by the application of a small moveable scale called a *Vernier*, (from the name of its inventor*,) a rise or fall of $\frac{1}{100}$th of an inch in the barometric column can be accurately read off.

From the length of that article, we did not enter into any detail on the subject of the important invention which we have now chosen for a title, preferring to consider the subject under a separate head, especially as the barometric application of the vernier is but one individual instance of its utility; it being a contrivance of universal application to all instruments adapted to the measurement of length, whether curvilinear—as the arc of a circle—or rectilinear; and as superficial and cubical measurement are but multiplied applications of linear measurement, the vernier enjoys an extensive range of operation. The sliding rule of the humble carpenter, the quadrant or sextant of the navigator, and the micrometer of the scientific astronomer, all receive an impress of value from this little instrument; indeed, there is no science that we can at present call to mind wherein it is not necessary to measure length, breadth, and thickness, and this often with a degree of exactness so rigid, as to excite surprise in the minds of the uninitiated, and to elicit an inquiry as to how such minuteness can be attained, and, when attained, how we are sure that it is exact. The object, therefore, of the present article, is to answer these two questions, and we feel assured that a little attention on the part of the reader will have the effect of preventing the vernier from being in future the *un*employed *attaché* to several useful instruments which it is now, in the hands of very many persons who lay no claim to the title of scientific.

Before entering upon the subject of the vernier, we propose to give a short account of the origin and nature of the standard measures and weights both of this country and of France, feeling assured that a subject of such universal importance will not be out of place here. In this country it is usual to refer all our measures of length to the standard yard, which has been determined by modern science with rigid exactness; indeed, so necessary is it to know the precise length of our yard, that some of the sciences which are now among the beautiful and the true, and beautiful because true, owe their very lustre to the precision with which our instruments measure lengths and capacities of various kinds. In a rude state of society the standard measure of length was some natural object, and as such, it was liable to constant variation; thus the yard itself was a measure of the length of the arm of one of the early kings of England (it is said of Henry the First, in 1101). Again, three grains of barley placed end to end were taken as the measure of an inch, thirty-six of which went to the yard*. Now this seems to imply that the arm of a king ought to be just as long as 108 barley-corns, but as we all know that neither kings' arms nor barley-corns are always of the same length, it is obvious that this method was not adapted to much precision; advancing science called loudly for some unerring standard, for some rule which would have all the rigour and truth of a principle which could be appealed to in after-ages, so that the accidents of fire, storm, or tumult, and the many casualties to which our lineal measures are subject, might not prevent posterity from deciding the real meaning of our distances, whether in the records of history or science.

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* Peter Vernier, a distinguished person in Franche Comté. The Vernier is also sometimes called the Nonius.

In 1760 a brass standard measure of one yard, made by Bird, was deposited with the clerk of the House of Commons, and in so far it gave an uniformity to the length of the yard in this country, but still no general principle was known by which that yard could be replaced if lost; and it was not until 1824 that an undeviating rule was laid down, which, by being based upon scientific principles, became available for after ages, as well as for our own times. Its origin is briefly this. The science of astronomy informs us, that the length of the day and the night, taken together, does not vary; also, that when a pendulum is made to vibrate, the time that it occupies in moving from side to side (which motion is called a vibration) is due altogether to its length, and has nothing to do with the quantity or quality of the matter of which the pendulum is formed. It follows, therefore, that all pendulums of the same length will perform the same number of beats or vibrations in the same time, with this especial proviso—that the observations are made at places all having the same terrestrial latitude. This condition is rendered necessary by a change in the force of gravity, which occurs with every change of latitude. Centrifugal force is an antagonist power to gravitation, and is greater at the equator than at any other latitude, on account of the greater diurnal velocity of the surface of the earth at the equator: hence the force of gravity is diminished, and the number of pendulous oscillations in a second likewise diminished, or, which amounts to the same thing, the length of a pendulum to vibrate in a given time must be reduced as we approach the equator. Thus,—at London, which is in latitude 51° 31′, the length of the seconds' pendulum must be 39·1393 inches, while at Stockholm, in latitude 59° 20′, the length is 39·1654 inches. If, therefore, we note the number of beats in any one day of any number of pendulums of equal lengths, they will all be found equal to each other, the latitude remaining the same; and if we suppose a pendulum of a given length to vibrate as many times as there are seconds in a day of twenty-four hours, *i. e.*, 86,400, and if the length of such pendulum be called *a yard*, any mathematician or astronomer in after-ages could ascertain what is the length expressed by the term *yard* with the greatest degree of exactness, since all he would have to do would be to get the length of a pendulum vibrating 86,400 times in a day. The length of such a pendulum would not, however, be our yard; but, if its whole length be divided into 391,393 equal parts, 360,000 of such parts are taken as the *yard*, so that the pendulum vibrating seconds is longer than the yard by $\frac{31393}{391393}$ parts. This ratio between the lengths of the yard and of the seconds' pendulum was ascertained by the late Captain Kater a few years ago, and a bar of platinum was constructed by order of government, under the direction, we believe, of the same accurate observer, and deposited in the Tower of London. The length of this bar is exactly a yard; all measures therefore in common use may be compared with this as a standard, and corrected; and so long as this standard is carefully preserved, it will not be again necessary to have recourse to the pendulum.

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* The origin of all English *weights* was a corn of sound ripe wheat, taken out of the middle of the ear: thirty-two of these well dried made up the old penny-weight. This number was some time after the reign of Henry VII. reduced to twenty-four.

Among the stormy clouds of the French revolution, there appeared a few shining spots, whose brightness has not yet passed away, which shone upon deeds that have outlived the impulse which gave them birth, and which men of science will always appreciate and value, when the tumultuous reign of terror shall be remembered only in the neglected page of history. From among these boons to posterity we select two examples; First, the almost universal use of the decimal notation in arithmetical processes, when applied to the arts and sciences; and *secondly*, a highly philosophical standard of weights and measures:—the extremely simple bonds by which all the modern French weights and measures are connected we now proceed to show.

The systematical form of the spheroid, into which the earth is thrown by its diurnal rotation, renders the distance from the equator to the pole physically and almost mathematically equal in every longitude, and in either hemisphere; a meridional quadrant of the earth's circumference is therefore considered as a constant quantity; this is, in English terms, 6213 miles, 1450 yards, and is divided into 10,000,000 equal parts, called METRES, each of which is consequently equal to 39·3709 English inches. This mètre forms a nucleus, from which multiples and submultiples branch off to express longer and shorter distances; thus, the decamètre, hectomètre, kilomètre, and the myriomètre, are respectively equal to 10, 100, 1000, and 10,000 mètres, and the decimètre, centimètre, and millimètre, signify the 10th, the 100th, and the 1000th of a mètre, Greek prefixes being employed for the augmented measures, and Latin prefixes for the aliquot parts. This is the standard for linear dimensions, but superficies is reckoned by the ARE, which is a square decamètre, of which each side is equal in English to very nearly 32 feet 8 inches. From this proceeds a series similar to that before given—viz., the miriare, kilare, hectare, decare, are, deciare, centiare, respectively equal to 10,000, 1000, 100, 10, 1, 01, and 001 ares.

From the decimètre cube is derived the unit of measures of capacity for liquid or dry substances, under the name of the LITRE, each side of which is equal to about four English inches square, and from this they have the decalitre, hecatolitre, kilolitre, and the myriolitre, respectively equal to 10, 100, 1000, and 10,000 litres; and the decilitre, centilitre, and millilitre, severally equal to 0·1, 0·01, and 0·001 litres.

For solid substances, the names of the units are different, but the principle is the same, the stere and the decistere being, the former a mètre cube, and the latter the tenth of a mètre cube.

The last link in this connected chain is the standard of weight, which is derived from the mètre thus: the weight of a centimètre cube of distilled water is ascertained at the temperature of its greatest condensation, or 39·38 Fahr., and is called a GRAMME. From this seven others are derived, which, with it, form a decimal series, thus: myriogramme, kilogramme, hecatogramme, decagramme, *gramme*, decigramme, centigramme, and milligramme, being respectively equal to 10,000, 1000, 100, 10, 1, 01, 001, and 0001 grammes, the gramme being a cube of water whose side measures 0·3937 inches, or rather more than one third of an inch in length.

Thus we see that, if the English reader impress upon his mind the figures 3937, (which will be sufficient for ordinary purposes,) he will be enabled to translate French weights and measures into equivalent quantities expressed in English inches, by observing where to place the decimal point: for example,—

		English inches.
Myriomètre - - -	=	393700
Kilomètre - - -	=	39370
Hecatomètre - -	=	3937
Decamètre - -	=	393·7
Mètre - - - -	=	39·37
Decimètre - -	=	3·937
Centimètre - - -	=	0·3937
Millimètre - -	=	0·03937

And if we remember that the measure of superficies, of capacity, of solidity, and of weight, are all derived either from the mètre or one of its aliquot parts, we shall see that the same four figures, 3937, will be an index, available for the whole series of measurements.

It is much to be desired that English weights and measures were assimilated to those we have been describing, as there is now no general principle by which one species of measurement can be readily deduced from another. The custom of ages has, however, so bound up the received standards of weight and measure with the technical calculations of the artificer and of the retail dealer, that any attempts at change on a scale so extensive would meet with obstacles almost insurmountable.

Having now thus briefly shown the principle on which the French weights and measures are computed, we will revert to the English inch in describing the vernier, as it will bring more familiarly before the notice of the English reader the illustrations which we shall have occasion to adopt.

The length of the yard being satisfactorily established by the imperial platinum standard, its divisions and subdivisions into feet, inches, &c., necessarily follow, but, as we before stated, our purpose is to show how the inch can be broken up into a very large number of parts— 10,000 for example; and of these parts, so few as one or two be taken without any chance of error. This is effected by means of the vernier, and the process consists in placing in juxtaposition two graduated scales, between which there exists a known relation, and the *want* of coincidence between the dividing lines of the two scales shows by how much one division exceeds another. Let us take a familiar instance as an example. We have a line, A, B, fig. 1, of which we wish to ascertain the length: we take a graduated scale, C, D, say three inches long, and divided into tenths of an inch, and applying one end of the line to the zero of the scale, we perceive that the other end coincides with a point between the fourteenth and fifteenth divisions of the scale, and we thus know that the line is rather more than 1$\frac{4}{10}$th inches in length. This would be sufficiently accurate for ordinary purposes; but if it were desirable to estimate what portion of the next tenth of an inch is meant when we say "rather more," another scale is constructed, divided also into equal parts, each of which parts is larger than the divisions of the original scale.

Fig. 1.

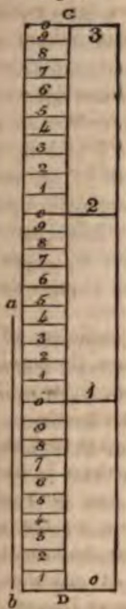
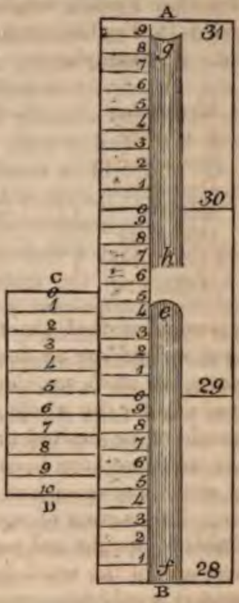


Fig. 2.



As nothing assists the comprehension of a written description so much as a little mechanical contrivance to illustrate it, we would recommend the young student in science to furnish himself with two pieces of card, carefully graduated according to the following figure. Fig. 2, A, B, is a slip of card exactly three inches in length, and about three-quarters of an inch in width, and the length is divided into tenths of an inch, of which there are of course thirty; the figures 28, 29, 30, and 31, relate to the barometer, to which we shall presently refer. C D is another slip of card exactly 1$\frac{1}{10}$th inch in length, and divided into ten equal parts; the two scales are numbered, the one from the bottom upwards, and the other from the top downwards; let the short scale be called a vernier, and the reader, with the two slips of card in his hand, will be prepared to follow the principle of its application as contained in the following details.

As ten divisions on the vernier, fig. 2, are together equal to eleven on the scale, and as those ten are all equal to each other, it follows that each division of the former must be equal to $1\frac{1}{10}$th divisions of the latter, or to $\frac{11}{100}$ths, which is the same thing; if, therefore, any two divisions, one on each scale, coincide with or are parallel to each other, the next pair above or below them deviates from a similar coincidence by a quantity exactly equal to $\frac{1}{100}$th of an inch; the pair two degrees removed from the first has a deviation of $\frac{2}{100}$ths or $\frac{1}{50}$th of an inch, and so on: thus, in our engraving, 6 on the vernier coincides with 9 on the scale, but a little consideration will show that the two figures immediately above them (5 and 0) do not exactly coincide, that the distance between them is only $\frac{1}{10}$th of $\frac{1}{10}$th of an inch, or 100th of an inch; proceeding to the two figures next higher, which are 4 and 1, we shall have no difficulty in perceiving that their deviation from coincidence is $\frac{2}{100}$ths of an inch; in like manner, the next pair are vertically distant from each other $\frac{3}{100}$ths of an inch, and in regular succession 2 and 3, 1 and 4, 0 and 5, form couples which deviate from coincidence respectively $\frac{4}{100}$ths, $\frac{5}{100}$ths, $\frac{6}{100}$ths of an inch. But this is not all; we shall find that the same reasoning precisely will apply with reference to the pairs situated below the parallel lines 6 and 9; thus 7 and 8, immediately below them, are deficient in coincidence by $\frac{1}{100}$th of an inch, and the same series of numbers increases downwards as increased upwards in the former case. The circumstance which the reader has constantly to bear in mind being this—that a degree on the vernier is $\frac{1}{100}$th of an inch larger than a degree on the scale; from this the results detailed above follow, as a necessary consequence.

Now, for the application of this property: suppose *e f* to be the upper part of the mercurial column of a barometer, and we wish to ascertain the height to which it has attained to within $\frac{1}{100}$th of an inch; we see, in the first place, from the scale to which the barometer column is attached, that the height is somewhat more than $29\frac{1}{2}$ inches, or 29·5. In order, then, to estimate correctly how much of the next tenth of an inch is omitted in this statement, we place the zero or 0 of the vernier scale exactly parallel to the top of the mercury; we shall next observe that, out of the eleven lines of division on the vernier, one will coincide with one dividing line on the scale, but *only* one can do so. In our figure the number 6 on the vernier coincides with the ninth line on the scale. Let us now determine what is the value of this figure (6) in our computation: as 6 and 9 are coincident or equal in height, 5 and 0 must, according to what was before stated, be $\frac{1}{100}$th of an inch distant from each other, 4 and 1 be $\frac{2}{100}$ths, and 3 and 2, 2 and 3, 1 and 4, 0 and 5, be respectively $\frac{3}{100}$ths, $\frac{4}{100}$ths, $\frac{5}{100}$ths, and $\frac{6}{100}$ths of an inch distant from each other. The last pair is that with which we have now to do: as 0 on the vernier is distant $\frac{6}{100}$ths of an inch from 5 on the scale, it follows that that same quantity is the distance from the top of the mercury to the figure 5 immediately below it on the scale, as the top of the mercury coincides with 0 on the vernier; and we thus arrive at the conclusion, that the height of the mercurial column is $29\frac{1}{2}$ inches, and $\frac{6}{100}$ths of another inch, or, expressed decimally, 29·56. The circumstance of the top of the vernier being marked 0, gives us this advantage, that the figure on the vernier, which is attached to the coinciding line, will always express the number of hundredths of an inch which are to be taken into account. The reason is obvious; from the top of the mercury to the coinciding lines there are six pairs of lines, each of which deviates from coincidence by $\frac{1}{100}$th of an inch more than the one preceding it, and thus the $\frac{6}{100}$ths are formed.

We have chosen a case in which the upper surface of the mercury is convex, as it always is when the mercury is rising; but the same mode will apply when it is concave, and the same diagram will serve to illustrate it. Suppose *g h* be the upper part of our mercurial column, and we wish to determine its height, we perceive that the indication on the scale is $38\frac{8}{10}$ inches, and a portion of another tenth, which our vernier must measure; we place the zero of the vernier on a level with *g*, the top of the mercury, and we shall then find that 8 on the vernier coincides with 0 on the scale. We know from this that 7 must be $\frac{1}{100}$th of an inch higher than 1, 6 $\frac{2}{100}$ths of an inch higher than 2, and so on to the top, by which we shall obtain $\frac{8}{100}$ths; accordingly 8 is the number attached to the coinciding line of the vernier; and we arrive at the final result, $30\frac{8}{10}$ths and $\frac{8}{100}$ths, or 30·88 inches, as the height of the mercurial column. It thus appears that it is not necessary to reckon the number of times that the corresponding lines deviate further from coincidence. Place the zero of the vernier to the extreme end of the object to be measured, and the figure attached to the coinciding line will represent the number of hundredths of an inch which are to form part of the computation.

We have been describing a vernier in which the figures proceed in an opposite direction to that followed by the figures on an original scale; but there are a great number of instruments in which the numbers proceed in the same direction both in the scale and in the vernier, and the reader may suppose that a new or a different principle is involved in the construction of the latter; but, as it is very important in science not to consider that to be a *new* principle which is only a modification of another already employed, we deem it necessary to state wherein consists the difference between a vernier in which the figures follow the same direction as those of the scale, and a vernier in which they follow the opposite direction.

The whole circumstance rests upon this ground: that when the figures proceed in opposite directions, the degrees on the vernier are larger than those on the scale; but when the figures proceed in the same direction in both, the degrees on the scale are larger than those on the vernier. This we will illustrate. In our former instance, the scale was divided into tenths of an inch, and the vernier was $1\frac{1}{10}$th inches in length, and divided into ten equal parts, which were individually larger, therefore, than those of the scale; but in the present instance the vernier is $\frac{9}{10}$ths of an inch long*, and being divided, as before, into ten equal parts, the length of a degree on the vernier is to that of a degree on the scale as 9 to 10; consequently a degree on the latter is $\frac{1}{100}$th of an inch larger than a degree on the former. Let us see how this operates in practice. We have (fig. 3,) a column of mercury, *e f*, whose elevation we wish to measure. We perceive its proximate height to be $29\frac{7}{10}$ths inches, but there is an overplus left uncomputed. We apply the vernier last described in such a manner that the figure 10 shall coincide with the top of the mercury, and we find that 4 on the vernier coincides with 2 on the scale; and we decide that the height is $29\frac{7}{10}$ths and $\frac{4}{100}$ths, or 29·74 inches. The manner of explaining this is, in some respects, more difficult than with the other vernier, but we think the following will suffice:—If 0 on the vernier coincide with 8 on the scale, 10 on the vernier would coincide with the next higher 7 on the scale; but in order that that same number 10 should coincide with the top of the mercury, the vernier must be slightly raised, and the quantity which is so raised is reckoned by the number of degrees from the bottom before we arrive at a coinciding pair of divisions, which in this case is 4; because if 4 and 2 coincide, 3 and 1 want $\frac{1}{100}$th of an inch of coincidence, and 2 and 0, 1 and 9, 0 and 8, want, respectively, $\frac{2}{100}$ths, $\frac{3}{100}$ths, and $\frac{4}{100}$ths of an inch of coincidence.

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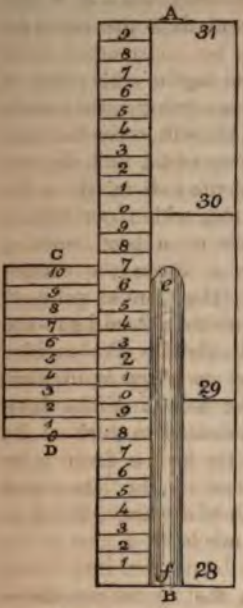
* Hence the vernier has been sometimes called in England a *nonius*, from the Latin numerical adjective *nonus*, nine.

Fig. 3.



It thus appears that so far as utility is concerned, it matters little what sort of vernier is employed, the only points necessary to be borne in mind being these:—1st, that when the numbers on the vernier proceed in an opposite direction to those of the scale, 10 degrees of the former must be equal to 11 degrees of the latter, and the *zero* or 0 of the vernier must be applied to the end of the object to be measured. 2nd, that when the numbers on the vernier and those on the scale proceed in the same direction, 10 degrees of the former must be equal to 9 degrees of the latter, and the division marked 10 on the vernier must be applied to the end of the object to be measured. The reader who constructs for his own use a vernier of either kind, must bear in mind, that whether it be $\frac{11}{10}$ths or $\frac{9}{10}$ths of an inch in length, it must be divided into 10 equal parts, otherwise the decimal notation, so eminently convenient in practice, would not be available for his instrument; for if 9 degrees on the vernier were equal to 10 degrees on the scale, a degree on the former would be $\frac{1}{9}$th greater than a degree on the latter; but if they were in the ratio of 10 to 11, a degree on the former would be $\frac{1}{10}$th greater than one on the latter, or, expressed in proportionals—

As $9 : 10 :: 1 : 1\frac{1}{9}$
And again— As $10 : 11 :: 1 : 1\frac{1}{10}$

And this is the proportion for which the decimal notation is so available.

The vernier, as we have hitherto considered it, is applicable to rectilinear divisions: it can, however, be applied with equal facility to *circular* divisions, such as those which form essential parts of the quadrant, sextant, and instruments employed in the measurement of angles. The vernier is, in such cases, a segment of a circle which is concentric with the segment of the circle forming the scale. But here we have to allude to a circumstance which gives rise to a different gradation of the vernier. In our previous details, an inch on the scale is supposed to be divided into 10 equal parts, and the vernier to be constructed with degrees, either $\frac{1}{10}$th greater or $\frac{1}{10}$th less than those on the scale; but it is obvious that any other standard may be assumed, according to the necessities of the case: for instance, a degree of a circle is neither divided into 10ths nor 100ths, but into 60ths,—60 minutes being equal to 1 degree; consequently the decimal notation would lead to confusion in the subdivision of the scale. Whether or not it would be desirable to substitute 10ths, 100ths, 1000ths, &c., of a degree for the present series of minutes, seconds, &c., in English scientific observations, is a separate question: we are decidedly of opinion that it would; but, as things are at present, the vernier attached to graduated arcs must be regulated according to the sexagesimal system, unless the degree itself be previously divided into three or six equal parts: thus, we have now before us a quadrant, constructed by Nairne, in which each degree of the arc is divided into three equal parts, and to this is attached a vernier so graduated that 20 of its divisions shall be together equal to 19 of those on the arc: a division on the former, therefore, is $\frac{1}{20}$th smaller than a division on the latter, and by its means we can measure $\frac{1}{20}$th of $\frac{1}{3}$rds, or $\frac{1}{60}$th of a degree, which is equal to one minute, or, expressed in the usual symbols, $0^\circ\ 1'$.

As we have now shown that the vernier may be divided into either 10 or 20 equal parts, so it might easily be shown that it admits, theoretically, of a division into 100 equal parts in a similar manner; and that, by its means, $\frac{1}{1000}$th of an inch could be measured: thus, suppose we had a scale 10 inches in length, and divided into 10ths of an inch, of which of course there would be 100; and that we construct a vernier either $10\frac{1}{10}$th inches, or $9\frac{9}{10}$th inches in length, and divided into 100 equal parts; it is obvious that if any line on the vernier coincided with a line on the scale, the next pair above them would deviate from coincidence by a quantity equal to $\frac{1}{100}$th of $\frac{1}{10}$th of an inch, or $\frac{1}{1000}$th of an inch. In fact, we may state generally that the only limit to the micrometrical power of the vernier is the limit to our power of mechanical contrivance; for as the lines which we engrave on our scales have an appreciable thickness, any quantity less than that thickness cannot be measured by its means, even admitting the accuracy of division to be rigorous. Supposing, however, the graduation to be correctly done, the power of the vernier is greatly increased by the following little contrivance.

The vernier is, in some delicate instruments, moved by means of a screw, which, passing through a female screw cut in a fixed collar, is so arranged that, in turning upon its axis, it moves either backwards or forwards. The other end of the screw, instead of the usual thread, (which here terminates about half-way up,) has, cut upon it, the divisions of the vernier. On taking hold of the head of the screw, a very slight turn will be found to alter the relation of the vernier to the scale; and the advantage gained is, that the screw enables the observer to adjust the one to the other with great nicety: if the divisions are very small, the eye may be assisted in this adjustment by the employment of a small double-convex lens attached to the instrument.

Here it will be seen that the screw is only employed to produce a slow and gradual motion; but if we suppose the screw to be cut with perfect accuracy, and that its threads are quite regular, it follows that the very motion of the screw round its axis can be made subservient to the purposes of subdivision. To effect this we must suppose two things,—1st, that the two screws are accurately fitted to each other; 2nd, that the threads of the screws are perfectly homogeneous. These conditions fulfilled, then it follows that for every turn of the screw upon its axis, the vernier will advance or recede a distance which is equal to that contained between two contiguous threads of the screw; and for a half or quarter turn, the advance or recession will be the half or the quarter of this interval. It becomes easy, then, to determine these fractions, by tracing upon the border of the head of the screw a circular division of equal parts, which shall bear a known relation to the principal scale; for if this graduation of the circle be into 100 equal parts, in turning the screw of one of these parts, the motion of the vernier will amount to only the $\frac{1}{100}$th part of the distance between two contiguous threads of the screw; so that, supposing the vernier and the scale to which it is attached to be adapted to the measurement of $\frac{1}{1000}$th of an inch, the motion of the screw through one of its divisions will give the 100,000th part of an inch as the result of the combined action of the vernier and the screw. Thus, it will be seen how an inch may be divided, by a nice adaptation of the vernier, into a very large number of equal parts,—from 100 to 100,000.

Our object in writing this paper has not been to describe the niceties of apparatus, and the many ingenious contrivances which science, art, and industry have in store for the attainment of that important object and aim of science; viz., accuracy: this, however delightful and important, would have led us too far: our desire has been to impress upon the reader's mind the *principle* of the vernier; for he must never forget that the possession of a number of facts unconnected by principles, is like the possession of a fund of anecdote and wit; it is merely *amusing*. Society is now generally becoming attached to the *utile* as well as to the *dulce*: it will applaud that which amuses the idle hour, but it will generally value and respect that which can render the idle hour not merely amusing, but profitable.

A POPULAR COURSE OF GEOLOGY.

XI.

ORDER OF ARRANGEMENT OF MATERIALS COMPOSING THE CRUST OF THE EARTH.

GEOLOGY has been defined to be, in its most extended sense, the ancient natural history of the earth, and of the changes which have taken place in the organic and inorganic kingdoms of nature. It teaches us the materials of which the earth, to a certain depth, is composed, and the order in which they are arranged. We obtain this knowledge by means of observation, aided in some degree by inductive reasoning. We carry this inductive process further, and are enabled to discover the agencies which were employed in the formation of the crust of the earth, the convulsions and revolutions to which it has been subject, and the various races of beings which have successively inhabited its surface during a series of epochs of long-protracted duration.

The former part of the inquiry, namely, that which relates to the materials composing the earth's crust, and the order in which they are arranged, forms the practical and elementary part of geology; the latter may be called theoretical or speculative geology; but, conducted as this is at present, it must not be confounded with the speculations of the cosmogonists.

When we speak of the high antiquity of the globe, of extinct races of animals and plants, of central heat, and of change of climate, we are sometimes accused of indulging in reveries scarcely less visionary than those which we condemn in Burnet and Whiston, and the other writers of that school. There is, however, a wide difference between their speculations as to the mode in which the world was created, and the investigations of modern inductive geology respecting the changes which the surface has undergone since its creation, and we have as conclusive evidence of the disappearance of one race of animals and plants, and of their having been succeeded by others, as we have, independently of history, of the existence of the Egyptians, Greeks, or any other nation of antiquity.

History informs us that England was first inhabited by the Britons, and that it was successively conquered by the Romans, the Saxons, the Danes, and the Normans; and we find in our island coins, weapons, and other monuments of all these different nations, to confirm the accounts of history. But confined, as these remains are, to the superficial soil, and not unfrequently blended together, it would be difficult, in the absence of history or tradition, to disprove the assertion that these tribes were all contemporaneous inhabitants of the country, much less could we prove that a considerable length of time elapsed between their different immigrations. The case, however, would be different, should we find these remains arranged in the following manner:—Let us suppose that in a certain part of England, we will say its western coast, we should find the remains of a town, buried, like some villages on the coast of Ireland, beneath heaps of blown sand, and that in this town were found inscriptions in the English language, and a series of coins from the time of Charles I. to the reign of Queen Anne. It would be a sound inference that this town had been inhabited by the English during the interval between those reigns, and that it was overwhelmed with sand during or immediately after the close of the latter reign. Let us suppose, again, that in excavating beneath the foundations of this town we should find the ruins of another, consisting of burned and blackened bricks and stones mixed with calcined human bones and fragments of burned timber, together with coins and medals, and the least perishable articles of dress and furniture, all exhibiting appearances of having passed through the fire; and let us suppose that the most ancient coins met with were of the reign of Henry VIII., and the most recent those of the early part of the reign of Charles I. We should conclude that this town had been burned during that reign, and that on its ruins had arisen another which had subsequently been covered by sand. Let us further suppose that in sinking a well a bed of clay four or five feet thick should be met with beneath the ruins of the burned town; that this clay contained the remains of land-animals, mixed with thin and fragile shells, such as those which inhabit fresh water, and which proved, on examination, to be identical in species with those still inhabiting lakes and stagnant pools in the neighbourhood. We could scarcely avoid the conclusion that a lake had formerly existed on this spot, which had either been laid dry by some natural process, or had been drained artificially, and that on its site had been founded the town which was burned in the reign of Charles I.

We will now suppose that in the immediate vicinity there was a volcano subject to periodical eruptions after intervals of repose of a few years' duration; that streams of lava had been seen to flow from it, and to cool into solid rock; that at other times fine ashes and scoriæ ejected from its crater, and mixed with water, had been seen to form mud, and to solidify into a rock of an earthy appearance, called volcanic tufa, while occasionally torrents of hot mud were known to have burst forth from the crater, and to have hardened into the same kind of tufa.

Let us suppose, likewise, that beds of lava might be traced from the sides of this mountain till they were seen to run under the stratum of clay forming the bottom of the ancient lake, and that on sinking through the clay and lava another town should be met with in the same state as the cities of Pompeii and Herculaneum; we should conclude, though we had never heard of those cities, and of the mode of their destruction, that this town had been overwhelmed by an eruption of the neighbouring volcano, and that a lake had subsequently formed in a hollow on the surface of the lava. We will suppose that the implements and articles of dress and furniture found in this town were of a very different kind from those found in the former town, and that the inscriptions on the monuments and public works were in Latin instead of in English, we should learn from these circumstances that the modern English were not the original inhabitants of the country, but that they had been preceded by another people of different language and manners, who had inhabited it for a considerable period. Triumphs, sacrifices, feasts, marriages, and funerals, represented on medals and on the basso relievos of the public buildings, would give some insight into the manners and customs of this ancient people. In some of the houses at Pompeii there were found not only carbonized almonds and chestnuts, but even moist olives preserved in a glass-case, a loaf of bread retaining its shape, and marked with the name of the baker, was found in one shop; and in that of an apothecary was discovered a box of pills, with a small cylindrical roll by its side, evidently prepared to be cut into pills. Now, if in our supposititious Roman town in England fruits of the same kind were found,—if apparatus for making wine and oil were common in the houses,—and if, from the suddenness of the catastrophe, the wine-press or the olive-vat appeared to have been abandoned, on the approach of the lava, in the midst of one of these operations, it would be no visionary conclusion that during the Roman era the climate of England was warmer than at present, for the vine and the olive to bring their fruit to maturity, and to be cultivated for the purpose of making wine and oil; and we should thus learn another curious fact, that there had been a change of climate as well as a change of inhabitants.

Again, let us suppose this town to stand on a series of calcareous and argillaceous strata,—in other words, upon beds of marl and clay,—alternating with beds of lava, and that the strata of marl and clay, besides shells such as inhabit shallow estuaries, contained human remains and works of art,—that in the upper strata were found coins and fragments of pottery, like those of the Roman, or third city from the surface,—and that the lower beds, besides the estuary shells, contained the bones of stags, and buffaloes, and the tusks of wild boars, together with the canoes, stone hatchets, flint arrow-heads, and other relics of a rude tribe of hunters; while towards the middle of the series were strata containing the mingled remains of the two people. From the shells being marine, and of those genera and species that frequent brackish estuaries,—from their state of preservation,—and from their being found of every age from the young to that of full-grown individuals, with every indication of their having lived and died on the spot, we should conclude that at some remote period these strata had formed the mud and sand at the bottom of an estuary, into which rivers had borne down the remains of animals inhabiting the neighbouring forests; that some of the human remains had been conveyed into it by the same means, and that others had become imbedded by the swamping of the canoes of the savage, or the stranding of the navies of the civilized people.

Now as men do not build cities beneath the waters, we must conclude that this estuary had been converted into dry land, before the foundation of the Roman city whose fate it was to be overwhelmed by a volcanic eruption, and the beds of lava alternating with the marine strata would convince us that the volcanic action must have been going on in the neighbourhood for a considerable period before this catastrophe.

We will now suppose a shaft to be sunk to a still greater depth, either in the prosecution of some mining operation, or to satisfy the curiosity excited by these wonderful discoveries, the more wonderful because no tradition existed of the island having had any other inhabitants than the nation at present possessing it; and we will suppose that this shaft, in its progress, passed through a series of strata containing no human remains or works of art, but abounding in marine shells, we should then have satisfactory evidence that the tribe of hunters whose rude weapons and canoes were the lowest human remains met with, were the first people who inhabited the neighbouring land. Should we arrive at a point where beds of lava no longer occurred, we should ascertain the period when this volcano broke out. We will suppose that the shells also change their character in the lower beds, and are no longer estuary shells, but of such kinds as are found in deep water, and that beds of sandstone and conglomerate, containing no organic remains, are found at greater depths; and, finally, that a mass of granite is penetrated in which the operations are carried for several hundred feet, until the great depth of the shaft renders it impossible to prosecute the work further. The phenomena which we have been supposing to be discovered would afford satisfactory evidence of the following changes as having taken place on this spot.

We should have, in the ascending order—

1. A sea too deep in this place to support animal life, and having a rocky bottom of granite. On this bottom were thrown down the detritus of projecting peaks of granite, affording materials for the conglomerates and sandstones.

2. The depths of this abyss are in this way gradually filled up, till it is rendered habitable by molluscs frequenting deep water.

3. The process of filling up continues till this sea becomes a shallow estuary.

4. Volcanic action commences in the neighbourhood, and has continued in activity ever since. It was probably the means of elevating and laying dry parts of the bed of the sea, and of forming a continent or large island in the vicinity; for the remains of trees and of land animals are now found imbedded in the sedimentary deposits.

5. The neighbouring land is at length inhabited by a tribe of hunters, who continue to occupy it unmolested for some time, as their reliquiæ are the only human remains met with in a series of beds of considerable collective thickness.

6. The estuary becomes dry land; a nation in a more advanced stage of civilization colonizes the country, and builds a city, which, after the lapse of several generations, is buried beneath a torrent of lava.

7. A lake is formed in a hollow on the surface of this lava. It becomes filled up with sediment, or is drained artificially. A town is founded on its site, and is inhabited during the reigns of many kings by a race of people speaking the same language as the present inhabitants of the country.

8. This town is destroyed by fire, and another quickly springs up on its ruins, which is overwhelmed in its turn by heaps of blown sand.

In one respect we have followed the example of the cosmological writers; we have *assumed our data*. We have imagined active volcanoes in England, and have supposed them to have destroyed towns, after the manner of Herculaneum and Pompeii, which, as far as England is concerned, is a pure fiction. Neither is there known any locality in the *world in which* a similar succession of human fossil remains have been met with. In one place the remains of a town are found buried beneath sand; in another country a city, exactly in the state it was nearly two thousand years ago, has been preserved under a bed of lava. The skeletons, the rude weapons, and the canoes of the savage, have been found in the peat-moss and in the lacustine strata of marl on the ancient estuary below the peat; but beneath these there has never been found any succession of aqueous strata alternating with beds of lava, and containing human remains. Something of the kind might perhaps be found, could we have access to the strata now forming in the Mediterranean, in the vicinity of active volcanoes, and of those countries which were among the earliest habitations of the human race; but such formations are yet submarine.

We have supposed the succession of strata containing human remains described above, for the purpose of illustrating the kind of evidence by which we obtain information as to the changes which the same part of the earth's surface has at different times undergone, and for the purpose of showing the means by which it is rendered evident that time, and a long lapse of time, must have been required for the formation of the fossiliferous strata constituting the earth's crust. By means of the series of strata containing human remains, which we have supposed to be arranged over one another (had any such series existed), we should be able to prove, though history were silent on the subject, that this island had been successively peopled by several nations of different languages, manners, and customs. The data being given, the inferences would be conclusive. In the face of such a series, it would be the height of absurdity to assert that all those different nations inhabited England at the same time. In the above series, for England substitute our planet; for dead languages and extinct nations, substitute extinct races of animals; and for Britons, Romans, and modern English, substitute the Mastodon and Dinotherium, the Ichthyosaurus and Iguanodon, the Ammonite and the Trilobite, and the data are given by which we prove the high antiquity of the globe. In the case of human reliquiæ the antiquary ascribes many centuries to the duration of a people from finding the coins of a long succession of kings, and as he has learned the average duration of a generation of men, he can with precision determine the length of time during which successive people and dynasties possessed any region of the earth where these remains are found. Now what coins and medals are to the antiquary, organic remains, embedded in a vast series of strata, are to the geologist; a series so vast, that it furnishes him with proofs of the lapse of ages, during the progressive formation of the earth's crust, before which the centuries within which the researches of the antiquary are limited sink into insignificance.

The duration of those ages the geologist is unable at present, and perhaps never will be able, to define. One material element in the calculation is wanting, which we may never be able to obtain, namely, the average duration of the life of certain marine animals. Could we procure this information, we might arrive at an approximate knowledge of the duration of a geological epoch, that is to say, the time that elapsed during the formation of a given series of strata.

Thus when we find a *bed of* limestone only a few inches thick, containing a particular species of mollusc in every stage of its growth, from the young to the aged individuals, all appearing to have been quietly deposited in the sediment of the sea, and where we find no bed either above or below for more than one hundred yards, containing any of the same species, it appears an inevitable conclusion that the whole of the life-time of that species of mollusc was occupied in the formation of these few inches of rock; and if we knew the duration of that life, we might form some conjecture as to the least time required for the formation of the many miles in thickness of the fossiliferous strata.

Had such a series of strata as we have been supposing to have been discovered in Britain ever existed there, we should have learned from it, without the aid of history, that the island had successively been peopled by the Britons, Romans, and English; and reasoning on that case alone, we should probably have come to the erroneous conclusion that they were the only people who had ever inhabited it, and that Henry the Eighth was the immediate successor of the last Roman emperor whose medals and coins were found in our imaginary English Pompeii. In this plausible error we might have remained until the chronological series was completed by such a discovery as the following:—Suppose, in some distant part of England, there were a conical hill, the sides of which were covered with ashes and scoriæ, and that there were a funnel-shaped cavity in the centre, from which might be traced beds of rock identical in character with the beds of lava of the active volcano; we should have evidence that this neighbourhood had formerly been the theatre of volcanic eruptions, which had ceased before the commencement of history or tradition; and if in the neighbourhood of this extinct volcano there were a series of alternating aqueous and igneous rocks, containing human remains, commencing with the British, continued through the Roman and Saxon, and terminating in the Danish era; and if in a third locality we should find a series commencing with the Saxons, and continued to the reign of Queen Elizabeth, we should be able, by combining these phenomena, to complete the chronological series. On the other hand, into what historical errors should we fall by confining our generalizations to any one of those localities! So it is with geology. We imagine, after the careful examination of an extensive region of the earth, that we have completed the series of rocks, and that we have an unbroken record of the organic changes which have taken place upon our planet, from the epoch of its earliest habitable state to the present time; but no sooner have we arrived at this conclusion, than the study of some hitherto unexplored region convinces us that, in the district to which our observations had till then been confined, not only are certain terms of the series wanting in any given formation (by which is meant a group of rocks, having a certain general resemblance in the forms of their embedded fossils), but that a blank exists, in which the numerous terms of a new series must be introduced, connecting formations and systems of formation by that gradual transition from one animal form to another which prevails throughout nature, and the absence of which, in the case in question, ought to have put us on our guard, and to have led us to suspect that a chasm existed which future observations in some other *quarters* of the world would hereafter fill up.

Some of these local violations of continuity will be noticed hereafter, when describing the several formations in detail. It was necessary to advert to the subject now, in pointing out the kind of evidence by which we prove some of the doctrines of speculative geology respecting the lapse of time during which the world has been inhabited by animals, and respecting the organic and inorganic changes which have taken place upon its surface. Most writers on geology appear anxious to hasten to the generalizations, and to pass over the elementary details; and readers appear no less eager to do the same; but for the pupils this is not so easy as for the instructors. This is the reason why so few make any real progress in the science, and why many abandon it in despair and disgust. There is no more a royal road to geology than to any other branch of knowledge. In that, as in every science, there are certain rudiments to be mastered, before its higher branches can be studied with advantage or pleasure. Our object in the present undertaking is to confine ourselves chiefly to elementary details; to established facts and admitted inferences; and thus to prepare our readers for the profitable perusal of the many excellent geological works in which the discussion of questions that are still subjects of inquiry and investigation often forms a very prominent feature. This will be our aim as much as possible; but we shall not always be able strictly to adhere to it; as it is with the rocks which are the objects of our science, so it is with the different branches of the science itself. In classifying the rocks, we find that they often pass into one another by such insensible gradations, that it is impossible to draw a line of demarcation between them, and it is equally difficult to establish any well-defined boundary between practical and theoretical geology. The following are some of the most important facts of practical geology: that there is a regular order of succession among the rocks constituting the visible parts of the earth; that this order of succession is never inverted, and that the same stratum may be identified in distant localities by its embedded fossils, or, in other words, that over a considerable horizontal extent there is more constancy in the zoological than in the mineralogical characters of rocks. It is impossible to state these facts, and to notice the regular gradation among the organic remains in the ascending order of the strata through molluscs, crustaceans, fishes, reptiles, and mammalia, to the human race, without entering into discussions on the doctrine of progressive developement, and on the indications which some of these remains afford of a change of climate. So also it is impossible to treat of the volcanic rocks, without noticing the close analogy which subsists between them and the other unstratified rocks, or remarking on the probable igneous origin of these, and discussing the theories which ascribe to central heat and secular refrigeration, the upheaving of mountains, the elevation of continents, and the modification of climate. There are many persons well informed respecting the figure of the earth, and its physical features, whose knowledge of its structure does not extend beyond the popular notion that it consists of a heterogeneous mass, in which sand, clay, gravel, and a variety of rocks are blended together, with no more regularity than the ingredients of a plum-pudding. They suppose that this was its original condition, and that the present physical features of the surface, its mountains, seas, lakes, and valleys, existed from the beginning as we see them now. It is even possible to make the circuit of the globe without obtaining more correct information on this subject, so long as our observations are confined to the surface only; but no sooner do we begin to penetrate below the surface, though our researches may be limited within a very narrow area, than new views open upon us. There are many districts in which it is impossible even to sink a well, or to open a quarry for the repair of the roads, without discovering that the rocks are arranged in layers, and succeed one another in regular order. Much valuable, but local, and unconnected information, was thus obtained by miners and others engaged in subterranean operations; and these details, extended, combined, and generalized by geologists, laid the foundation of our knowledge of the structure of the earth.

The depth, however, to which this structure is laid open by the hand of man, is extremely limited; the deepest mine in the world penetrates little more than half a mile below the surface, or about the sixteen thousandth part of the distance from the surface to the centre of the globe. The convulsions which the crust of the earth has undergone have exposed its structure to a much greater depth.

In cliffs on the sides of ravines, on the banks of rivers, and on the sea-shore, the strata may frequently be seen resting upon one another in an inclined position, as represented in the annexed diagram, fig. 37, their original horizontal state having been disturbed by a force acting from below. These natural sections often extend for many miles, and the inclination of the beds causes them to emerge successively to the surface, and enables us to estimate the perpendicular thickness *a x* of the whole series of beds from *a* to *k*.

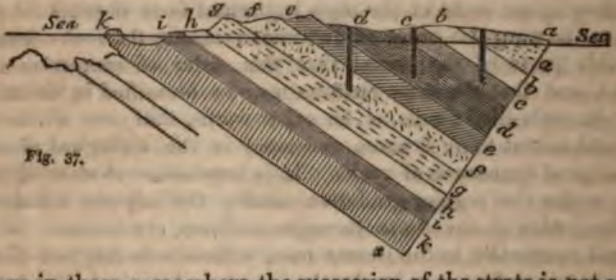


Fig. 37.

Even in those cases where the succession of the strata is not exposed to view in natural sections, their inclined position renders it possible by several independent sinkings of no great depth, made at different points, 1, 2, 3, judiciously selected, to prove the order of succession of the different layers, whereas had they remained horizontal, it would have been impossible to have ascertained this without sinking a shaft which would penetrate all the beds. By these means combined we obtain a knowledge of the structure of the earth to the depth of several miles, and over an extensive surface, and find that it consists of a great series of rocks arranged in regular order. The same kind of observations conducted in distant countries, demonstrate that similar series, maintaining an invariable order of succession, occur there also.

By extending these observations, we shall in time acquire an *accurate knowledge* of the geology of the entire globe. So far as these researches have hitherto gone, they show a remarkable identity in the older non-fossiliferous strata of the most distant regions. The fossiliferous rocks resting upon them are less uniform in their composition, so that in the series, *a*, *b*, *c*, *b* will be found, in one country, to consist of limestone, in another of calcareous sandstone, in a third of shale, and in a fourth of siliceous rock; but under all these altered aspects, its identity may be ascertained by its organic remains, taken as a group, and by its position with respect to the strata, *a* and *c*, above and below it.

In some cases we may travel along the upturned edge of a stratum for a considerable distance, so as to remove all doubts of its identity, and thus obtain ocular demonstration of the gradual change in its mineral character, the organic remains continuing the same. In other cases, where we have not this opportunity of observing the gradual change in composition, we infer the place in the series of two rocks at a distance from one another, and of a different mineral character, by the identity, as groups, of the organic remains of those two strata, and not only of those two, but also of those above and below them in each locality.

The information thus obtained, we represent on plans and in sections. A section shows the strata as they succeed each other in the earth, and it supposes a cutting of them in the same manner that, by cutting an onion, we show the different coats of which it is composed. All sections, when the contrary is not expressed, are supposed to be made perpendicular to a horizontal plane. In a plan, we lay down on a horizontal plane the superficial area occupied by each bed, as it rises to the surface, or, in the language of miners, *bassets* or *crops out*.

We trace and delineate the superficial boundaries of strata, by travelling across their basset edges in a number of parallel lines, noting on an accurate map of the country, the several points at which we pass from one kind of rock to another. Thus in the annexed diagram, fig. 38, in crossing the country intended to be represented by it in the line A B, A being supposed to be situated on sandstone, we should pass at *a* from sandstone to limestone, at *b* from limestone to slate, at *c* from slate to granite, at *d* from granite to slate again, at *e* from slate to limestone, at *f* from limestone to sandstone; and in traversing the same district along the lines C D and E F, we should find these changes take place at the points a' b' c' d e' f' and a'' b'' c'' d'' e'' f' respectively. In this way we construct geological maps, distinguishing by different colours the surface occupied by each kind of rock.

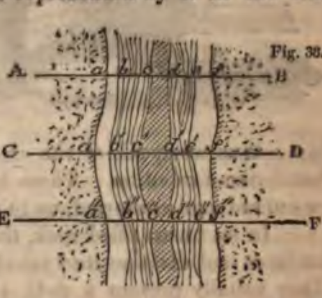


Fig. 38.

In speaking of a portion of the surface being occupied by any given rock, it must be observed, that over the greater part of the earth is spread a loose irregular covering of sand and gravel, not forming a component member of the series of rocks. Some of this gravel has been formed by atmospheric action, some may have been caused by local debacles or torrents, by the bursting of lakes, and by rivers having changed their beds; some may have been shot off the flanks of the nearest mountains during some period of elevation; but the greater part of it, in these islands at least, we consider to have been brought together by that great diluvial drift from the north, to which we have already alluded, and shall hereafter revert. In geological maps and sections, this loose covering is disregarded, and is not laid down unless attended with some remarkable peculiarities, which render it desirable to mark the spot where they occur, and that rock which lies immediately below it, is considered as rising to the surface.

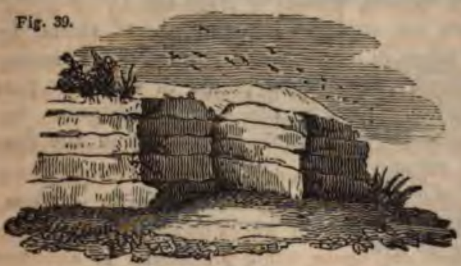
We must here observe, that the term, rock, is applied by geologists, not only to those hard stony masses commonly so called, but to clay, soft sandstone, and even to beds of incoherent sand, provided they constitute members of a series of strata or beds.

Classification of Rocks.—Stratification.—Dip.—Strike, &c.

Having ascertained that the crust of the earth consists of a great succession of rocks, laid one upon another in a certain order, our next endeavour is to classify them, or to arrange in groups those rocks between which the closest analogies exist, in order to aid the memory, embarrassed among the almost endless details of the numerous alternations of calcareous, argillaceous, and siliceous strata of which the series consists.

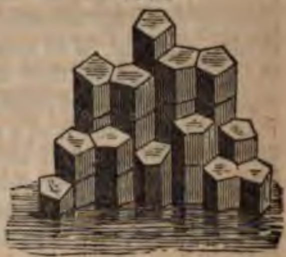
In entering upon this task, we soon discover a natural and obvious division of them into the *stratified* and the *unstratified*, a division founded on the appearances under which they present themselves to our observation as masses. A stratified rock is one whose boundary surfaces are parallel, or nearly parallel, for great distances, thus including a larger, or tabular mass, which is called a stratum or bed; and a number of these strata, possessing a common character, is called *a formation;* thus we speak of the chalk-formation, the lias-formation, the carboniferous-formation. These beds may be either horizontal, or vertical, or curved and contorted, as in fig. 43.

Fig. 39.



In an unstratified rock, there is none of this parallelism of bounding surfaces and division into tabular masses, continued for great distances. They usually present a rude amorphous appearance of irregular hummocks, but they are sometimes divided by vertical and horizontal joints into blocks of a regular shape, the most common form of which is that of a prism, having a rectangular base. This is frequently the case with granite. When the breadth of these blocks is considerable in proportion to their height, they often assume the appearance of beds, and the rocks in which they occur, have been in consequence mistaken for stratified rocks; but this kind of structure may be distinguished from true stratification, by the comparatively small spaces over which the parallel *bounding* surfaces of these false beds extend, and by the absence of bunds, or thin beds of rock, of a different composition from the rest of the mass alternating with these pseudo-strata. When the height of the blocks is considerably greater than their breadth, the rock in which they occur is said to have *a columnar* structure, a structure very common in basalt, porphyry, and greenstone.

Fig 40.



Sometimes these columns are continuous from the top to the bottom of the mass, in other cases they are jointed, and consist of a number of short prisms placed upon one another, fig. 40. This is the structure of the basaltic columns of the Giants' Causeway, where the prisms are in general hexagonal, though some occur with three, four, five, and eight sides. Quadrangular prisms are, however, the most common in rocks possessing the columnar structure.

Another natural division of rocks, founded on the mode of aggregation of their component parts, is into crystalline and sedimentary. Crystalline rocks are composed of one or more crystallized minerals, which must have been generated by chemical agency in the mass in which they occur, either from a state of fluidity, or under the influence of heat or electricity. Sedimentary rocks, on the contrary, consist of abraded fragments of older rocks in various states of attrition, brought together by mechanical agency, that is by the moving power of water. Granite, mica, schist, porphyry, basalt, and lava, are crystalline rocks; chalk, shale, sandstone, and conglomerates, are sedimentary in their origin. Rocks again are divided, according to the agencies employed in their formation, into two classes, the aqueous and the igneous.

The boundaries of these divisions into stratified and unstratified, crystalline and sedimentary, igneous and aqueous rocks, coincide to a certain extent, though not entirely. All the igneous rocks, for instance, are unstratified, but there are some rocks of undoubted igneous origin, which are not crystalline; there are, again, some limestones of aqueous origin, which are both crystalline and stratified; some of the lower stratified rocks are of a decided chemical and crystalline character, but their origin is involved in much obscurity; on the one hand, they graduate into rocks which appear to have been formed by igneous action, and on the other, into rocks which are decidedly fragmentary, and of aqueous formation; and there are again other rocks, which, even in hand-specimens, exhibit a blending of the crystalline and mechanical structure. We shall resume this subject, and endeavour to explain these apparent anomalies, when treating of the origin of rocks. As rocks in general admit of a natural classification into the stratified and unstratified, so they admit of another equally-natural division, into the fossiliferous and non-fossiliferous. Fossiliferous rocks are those, which, taken as a mass, contain organic remains; we say taken as a mass, for strata, though devoid of fossils, are classed among the fossiliferous series, if they alternate with beds which contain them. In forming the subordinate groups, no one principle *is applicable* to the whole series. The unstratified rocks consist of a few simple minerals, quartz, felspar, augite, hornblende, mica, chlorite, talc, diallage, and serpentine, variously combined; they rarely, if ever, contain organic remains; they occur in irregular masses beneath the other strata, or protruding through them, or traversing them vertically as dykes or veins; they have no constant relation to one another, or to the stratified rocks; it is impossible, therefore, to reduce them to a series, or to arrange them in chronological order, except in those cases where they occur associated with stratified rocks, whose relative position, and consequent age, is known. The unstratified rocks, therefore, only admit of a mineralogical classification, and many of them pass so insensibly into one another, by the absence of one particular mineral, and the presence of another, that it is a matter of no small difficulty, to frame a definite nomenclature for all those compounds; and it is frequently better to describe their composition, than to attempt to give them names. The same remark applies to the non-fossiliferous strata, which are so closely allied in composition to some of the igneous rocks. They admit of no other arrangement than one founded on their mineral character; they can scarcely be said to have any regular order, though, as a whole, the compounds called gneiss and mica-slate, occupy the lower parts.

On the other hand, a mineralogical classification is inapplicable to the fossiliferous rocks. Notwithstanding their great variety of colours and degrees of hardness, they can only be viewed, when considered mineralogically, as a series of clays, sandstones, and limestones, separated again and again. We have, for instance, frequent alternations of calcareous strata with shales and sandstones in the carboniferous series, with clay and sand in the oolitic, cretaceous, and tertiary systems; and there is, without doubt, a certain general difference between the limestones of these different eras; but, on the other hand, as we have before remarked, the animal composition of groups or particular beds is only characteristic of small areas. The carboniferous limestone of the southern parts of England, in which limestone is the prevailing rock, and coal does not occur, passes, in the north of England, into a series of shales, sandstones, and beds of coal, and the limestone becomes a subordinate member. So, also, the oolite of the south-west of England consists chiefly of calcareous strata, abounding in marine exuviæ. In Yorkshire it is represented by beds of sandstone and shale, associated with an inferior kind of coal or lignite, the organic remains are chiefly those of land-plants, and the marine remains are by no means numerous. The representatives of these strata among the Alps (the lower part of the Jura limestone) consist of indurated rocks, so closely resembling the calcareous parts of the slate-series, that they were for a long time confounded with them, and their real age was only discovered by the examination of their organic remains.

The cretaceous rocks are a family of extensive distribution in Europe, and are among the most persistent in their mineral character over large areas. The white chalk of the British islands prevails over a large part of France and Germany, and occurs in Poland, Sweden, and Prussia; but in the Alps, the rocks of this age (the upper part of the Jura limestone) as characterized by organic remains, consist of compact limestones and sandstones, equal in hardness to those of the older formations.

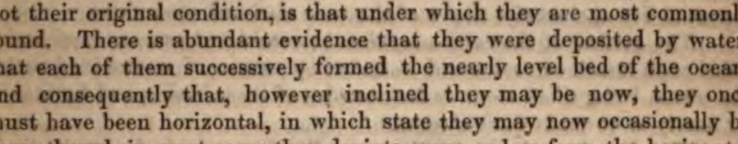
In the Pyrenees and Spain, according to Mr. Lyell, the rocks of the same era are represented by compact and crystalline marbles, conglomerates, red sandstone, their shales and grits containing fossils which are characteristic of the chalk in other parts of Europe. So again among the strata above, the chalk rocks occur, which possess precisely the mineral composition which was at one time deemed characteristic of older formations. There are tertiary limestones which, except by their fossils, cannot be distinguished, particularly in hand-specimens, from chalk and oolite, and there are tertiary arenaceous deposits which might be mistaken for the new red sandstone.

Brine-springs and beds of rock-salt were formerly considered characteristic of that formation; but in Spain they occur among the rocks of the age of our chalk, and in Poland in tertiary strata. The fossiliferous strata, therefore, must be classified according to the organic remains contained in them; and when we say that a given order of succession prevails among the stratified rocks, we mean that certain systems of strata, that is, of mineral substances, no matter of what kind, have been successively deposited at different distinct epochs, and that in those countries the structure of which has hitherto been most examined, they contain, as masses, certain general assemblages of fossils which are not to be found in the strata above or below them.

We have spoken of the inclined position of the stratified rocks as affording us an insight into the structure of the earth to a greater depth than would otherwise have been accessible to us. This, though evidently not their original condition, is that under which they are most commonly found. There is abundant evidence that they were deposited by water, that each of them successively formed the nearly level bed of the ocean, and consequently that, however inclined they may be now, they once must have been horizontal, in which state they may now occasionally be seen, though in most cases they deviate more or less from the horizontal position, are sometimes found highly inclined, or quite vertical, and often bent and contorted. They are always found to have the greatest inclination in the vicinity of masses of unstratified rocks.

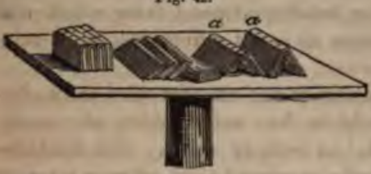
The centre of a chain of mountains consists in general of a mass of granite, or unstratified rock, on either side of which are found the stratified rocks, highly inclined, the non-fossiliferous strata being nearest to the unstratified rocks, and the fossiliferous strata succeeding them in that order which has been found, on the evidence of organic remains, to be invariable among them, so that the same series of beds is repeated in the same manner on each side of the chain, as in fig. 41, where *a* represents the unstratified rocks, *b* the non-fossiliferous strata, and *c* the fossiliferous. As the strata recede from the mountains, they become more horizontal, till in the plains they deviate very little from that position.

Fig. 41.



This inclination of strata is called their *dip*, the amount of which is expressed by the angle it makes with an horizontal plane, and its direction by the point of the compass to which the strata decline. The *strike*, or direction of a bed, is a line at right angles to its dip. If we place on a table a number of books, laid on one another, supported by another book, the table will represent the horizontal plane, and the angle which the tilted books make with the table will be the angle of their dip; that is, the more upright the books, the greater the dip, and the less they were tilted, the less the angle of the dip. The strike, or direction, again, would be represented by the lines of the backs of the books. If the books dipped towards the north and south, their strike would be east and west; if they dipped either to the east or the west, their strike would be north and south. Having found the dip of a stratum, or series of strata, we know the direction of the strike; but the converse will not hold good; the dip cannot be deduced from the strike, since there are two lines of dip common to each line of strike, and strata having a north and south strike, may dip either to the east or west.

Fig. 42.



In traversing the north of England, from west to east, we find the stratified rocks dipping from the Cambrian chain, westward to the Irish Sea, and eastward to the German Ocean, and the strata of the east of England pass under the sea, and rise again on the Continent with an inverted dip against the slopes of the west chain of mountains.

The surface of the earth may thus be considered as a series of basins filled with stratified rocks, and bounded by masses of unstratified rocks; the strata being tilted towards the outsides of these basins, and horizontal or nearly so towards their centres.

That line in a chain of hills or a valley from which the strata dip in two opposite directions is called an *anticlinal line*, or axis. If a book be placed half open on its edges, like the roof of a house (*a*, fig. 42), the line of the back of the book will represent an anticlinal line, and the leaves will represent the strata dipping in opposite directions, and the line along which the edge of the book meets the edge of another book placed parallel to it, will represent what is called a *synclinal* line, namely, that along which the strata dip towards each other. Anticlinal, as well as synclinal lines, may run either along the ridge of a hill, or the bottom of a valley, as shown in the annexed diagram, where *a a* represent anticlinal lines, on the summits of hills, and *á* an anticlinal line in a valley, in neither of which cases has the unstratified rock below been forced through the stratified rock as it has at *a″*. At *b* is a synclinal line running along the bottom of a valley, and *b′ b′* are synclinal lines on hills.

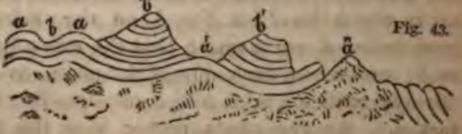


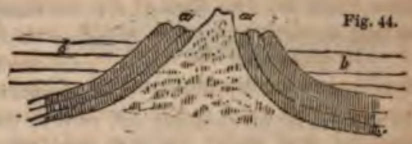
Fig. 43.

In some cases, a country is traversed by a series of anticlinal lines running parallel with each other for a considerable distance. In other cases one *set of anticlinal lines* is crossed by others having different directions. The broken and confused state of the strata under these latter circumstances may easily be imagined. North Wales affords instances of both these conditions. From the Menai Straits to near the English border, the anticlinal lines, having a direction a little east of north, and south of west, succeed one another with the greatest regularity of parallelism, and often within less than three miles of one another, so that fig. 43 nearly represents the state of the strata in the Cambrian range; but east of the Berwen chain these are crossed by other anticlinal lines, having a different direction, which have broken the strata up in all directions, and have given to them the appearance of the waves of a troubled sea.

When the planes of strata are parallel to one another, like the books of each series in fig. 42, they are said to be conformable; no matter whether their position be horizontal, vertical, or of any intermediate degree of elevation; but it has frequently happened that, after one set of strata were deposited, they have been tilted, and another set have been deposited horizontally either upon their upturned edges or abutting against them, in both of which cases the two sets of strata are said to be unconformable.

So in fig. 44, the beds of the series *a* are conformable to one another, but are unconformable to those of the series *b*. It may be observed here, that by means of this unconformable position of some strata in certain localities, we learn that all the chains of mountains in the world were not of contemporaneous origin, but have been upheaved at several successive epochs. Thus, if on the flanks of one chain we find a series of strata, *a*, fig. 44, tilted and covered unconformably by another set, *b*, it is obvious that the chain must have been thrown up after *a* was deposited, but before the formation of the series *b*; and if, on the flanks of another chain, the series *a* and *b* are still found tilted and covered unconformably by another set, *c*, we have evidence that this chain of mountains is of more recent origin than that on the flanks of which the strata *b* are undisturbed.

Fig. 44.



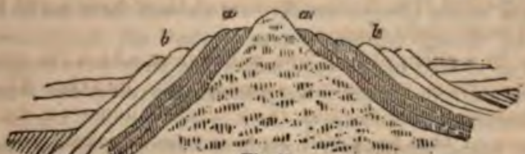
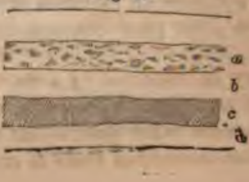


Fig. 45.

We have spoken of the strata having an invariable order of succession, and that this order is never inverted, but that in the series *a b c d*, *a*, *b* and *c* are never found below *d*, nor *a* and *b* below *c*, nor *a* below *b*; and when the sequence is not broken, *c* always rests on *d*, *b* on *c*, and *a* on *b*. It must not, however, be supposed that this is always the case; for, as we have already hinted, there have been *many* breaches of con-

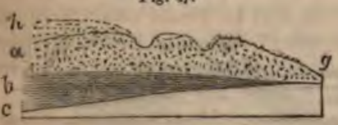
Fig. 46.



tinuity in the order of succession, so that between two given strata, not only is another stratum wanting, but in some cases a whole system of strata, which are found between those two beds in other localities. This may have arisen from two causes; either the missing beds may never have been formed on that spot, or after they were formed, they have been removed, or *denuded*, as it is called, by the abrading action of water, before the newer strata were deposited.

In cases where the strata rest unconformably on one another, as in fig. 45, very modern beds may be in contact with very ancient beds; and if we assume for the present what we shall hereafter produce evidence to prove, that the stratified rocks have been formed beneath the bed of the sea, and upraised by the unstratified rocks bursting out from below, and that there have been subsidences and re-elevations of parts of the earth's crust, we can readily account for the intermediate parts of the series not having been formed on that spot. The forces which tilted the older strata may have raised them above the surface of the sea; after remaining in that state for some time, they may have been again submerged. But in cases where there has been none of this violent disturbance, but the strata are conformable, we sometimes find a particular bed gradually diminishing in thickness, or *thinning off*, as it is termed, till it is lost entirely, as in the annexed diagram, fig. 47, and *a* is seen resting conformably on *c* at *g*, while, at *h*, *b* is largely developed, and *a b c* succeed each other in regular order. This very frequently happens with a single bed of a series or formation, and sometimes with a whole formation.

Fig. 47.



No sets of strata are universally continuous; there are no universally stratified rocks, though certain groups of them are found over such extensive areas as to lead to the conclusion that they were formed by very extensive and uniform causes. In general, the older the formation the greater is its extent.

In other cases, where two beds rest conformably on one another, and the upper surface of the lower bed *c* has been water-worn, as in fig. 48, before the upper one *b* was deposited, an intermediate bed or beds may have been formed on this spot, and subsequently removed by denudation. We have sometimes direct evidence of this, when we find *a* and *c* in contact, the sole remains of *b* being the portions lodged in the hollows in the surface of *c*, which thus escaped the abrading action which removed the rest of the bed.

Fig. 48.

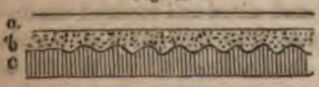
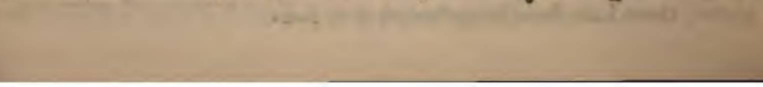


Fig. 49 represents a section extending over several miles, and exhibits an instance of an *overlap*, and an *outlier*. In this section *e* and *é* were once continuous portions of the same bed, which rested on, and

Fig. 49.



extended over, the edges of *a b c*. The portion of this overlapping bed, which connected *e* and *é*, having been removed by denudation, which also cut into the beds beneath, the deceptive appearance is produced of *e* having immediately succeeded *a*, whereas its real place in the series is after *d*. Insulated portions of a bed, or formation, like *a*, separated from the main body to which they belonged, are termed *outliers*. The continuity of a stratum in the same plane is frequently broken by fissures or dislocations, termed by miners faults, as represented in the annexed diagram, fig. 50. The strata at *a a*, *b b*, &c., were once continuous, but by a subsidence of the portion of rock on one side of the line of fault, or by an elevation of that on the other side, the beds became displaced, so that *á* is several feet lower than *a*, and abuts against the fractured end of *b*, while *b'* abuts against *c*. These fissures are sometimes a mere line, sometimes they are many feet in width, and are filled with clay or loose stones. They occasion great trouble and inconvenience in collieries by cutting off the beds of coal, and rendering it necessary to search for them in a different plane; but they are accompanied by counteracting advantages. In the first place, they counteract the tendency of the beds arising from their inclined position to plunge their lower ends to a depth that would be inaccessible but for these faults, which divide a bed of coal into several tables or stages elevated one above another (fig. 51), and so kept nearer the surface than they otherwise would be. And secondly, when filled with clay, as they often are, they perform another still more important office, by dividing a coal-field into a number of insulated sheets of rock, by dams impervious to water, and thus preventing its access in quantities which would be beyond the control of the most powerful machinery; and this would be the case had the beds of coal, and of grit and shale interstratified with them, remained continuously united.

Fig. 50.

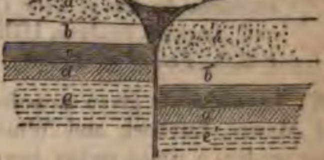
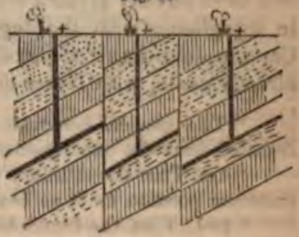


Fig. 51.



The displacement of the beds on either side of a fault does not, in general, amount to many feet; but it is sometimes on so large a scale as to occasion inequalities on the surface, which rank as mountains. The Penine chain, in the north of England, is caused by an enormous fault running north and south, which has thrown down the strata on its western side more than a thousand yards.

THE PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY, PART II., FOR 1836.

XV. *The Bakerian Lecture.—On the Tides of the Port of London. By* John William Lubbock, Esq. M.A., F.R.S.

XVII. *Researches on the Tides, Sixth Series. On the Results of an extensive System of Tide Observations made on the Coasts of Europe and America, in June,* 1835. *By the* Rev. William Whewell, M.A., F.R.S., *Fellow of Trinity College, Cambridge.*

WE have already given an account of some of the preceding researches of Messrs. Lubbock and Whewell, and purpose shortly to lay before our readers a continuation down to the time of our notice. We refrain, therefore, from further notice of this interesting series of researches in this place.

XVI. *Report of Magnetic Experiments tried on board an Iron Steam Vessel, &c. By* Edward J. Johnson, Esq., *Commander in the Royal Navy.*

WE have already given a very copious account of these experiments, but in compliance with the suggestions of some of our friends, we annex Captain Johnson's " General Conclusions deduced from the experiments already made, with Notes on those which are requisite to be tried."

" The general conclusions relating to practical purposes that may be deduced from the experiments already tried, are :—

" 1st. That the ordinary place for a steering-compass on board ship, is an improper position for it on board an iron steam-vessel.

" 2nd. That the binnacle-compass, in its usual place on board the Garryowen, is so much in error as not to be depended upon.

" 3rd. That in selecting a position for a steering-compass on board iron steam-vessels, it is requisite that it should be placed, as far as may be practicable, not only above the general mass of iron, but also above any smaller portions of iron in its vicinity, or that such portions of iron should be removed.

" 4th. That it never should be placed on a level with either the ends of horizontal or perpendicular bars of iron.

" 5th. That the extreme ends of an iron vessel are unfavourable positions, owing to magnetic influences, and that the connecting-rods, shafts, &c. of the machinery, being moveable quantities, renders the centre objectionable, independently of the position of the great iron funnel.

" 6th. That no favourable results were obtained by placing the compass below the deck, nor on a stage over the stern.

" 7th. That at the positions G, 20½ feet above the quarter-deck, and I, 13¼ feet above the same level, and about one seventh the length of the vessel from the stern, the deflections of the horizontal needle were less than those which have been observed in some of His Majesty's ships; but in order to prove whether this or a nearer approach to the deck may be fixed upon as a proper place for a steering-compass, the following experiments should be tried.

"The horizontal deflections at the different points as before, both with the fires lighted and extinguished. The dip and magnetic intensity to be ascertained, both when the vessel's head is at the true magnetic north and south, and likewise when it is at the north and south indicated by the needle at the position of observation on board; and further, that the vertical and horizontal vibrations should be determined when the vessel's head is towards the east and west; and it would tend to accuracy if these were obtained when the vessel was aground.

"It would be desirable to repeat some of the experiments after the keel of the vessel has remained some time in the line of the magnetic meridian, and afterwards to compare them with those which might be obtained after her head had been kept to the east and west for the same length of time.

"The vibrations of the needle, and a few bearings that could be quickly and accurately obtained after the vessel has been in motion through the water, would be desirable. The observations which were commenced on a needle placed in the centre of an iron sphere (3 feet in diameter) should be completed.

"As it is known that iron when heated to a red colour attains an extraordinary magnetic power, it would be advisable to observe whether a very delicately constructed needle suspended in the position where the compass is to be placed, be affected at such a distance from the furnace on board, and this should be accomplished when the vessel is aground.

"Similar experiments to those tried on the quay in Tarbert Bay might be repeated with advantage after the vessel has been in motion through the water, and needles ascertained to be of different intensities might be used.

"Besides ascertaining the horizontal deflections of the needle produced by the local attraction of the vessel, the object of some of the experiments above enumerated (and which suggested themselves to me during the course of my inquiry) is to determine whether the causes that affect the direction of the magnetic needle on board an iron steam-vessel, are constant or variable; and whether, should they prove to be the latter, that variation may amount to such a quantity as would be seriously detrimental in a practical point of view; or to prove that under ordinary circumstances the directive power will be sufficient for all the purposes required."

No considerations that have occurred to us since the composition of the aforesaid notice, nor yet anything which we have heard urged in opposition to the conclusions at which we there arrived, have in the smallest degree shaken our confidence in the truth of our conclusions. We are the more earnest in entreating the attention of scientific men and of the public, to those remarks, from seeing that manufactories, for the *express purpose* of building iron steamers, are springing up around us, and that some of them are already in operation.

There is one point, else, on which we would add one word. We find we have been somewhat misunderstood in our remarks on the value of Barlow's correcting plate. We did not by any means hold it up as a *perfect correction*, but distinctly stated that it was not so. To a certain extent, it is a corrector: but still there are cases conceivable in which its indications are *extremely fallacious*—and even of a *contrary character*. In general, however, it partially indicates the local attraction, and is hence worthy of the attention of the seaman. Our objection to it, however, on board an *iron steamer*, as worse than valueless, remains unaltered.

XVIII. *On the Powers on which the Functions of Life, in the more perfect Animals, depend, and on the Manner in which they are associated in the production of their more complicated Results.* By A. P. Wilson Philip, M.D., F.R.S., L. and E., &c.

"The following paper (remarks Dr. Philip, in a note) comprehends the result of a task, not of a few months or years, but, with the exception of the time devoted to the arduous duties of my profession, of the greater part of not a short life. As far as I can, to render what I have done useful, it is necessary that the various facts should be compared, and thus the inferences they afford ascertained. They are dispersed through so many publications, eleven papers in the Philosophical Transactions, published in the course of twenty years, an Inquiry into the Laws of the Vital Functions, a Treatise on the Influence of Minute Doses of Mercury in restoring the Functions of Health, my Gulstonian Lectures on the more obscure Affections of the Brain, &c., that although they are frequently referred to, it has almost always been, more or less, under mistaken views; because the writer, in commenting on one part, has been unacquainted with others with which it is intimately connected, for in so protracted an investigation, few will take the trouble to keep pace with the inquirer.

"It will appear from the references in the following paper how each of the various facts, dispersed through so many publications, has contributed to fill up the great outline of the laws that regulate the animal functions, which has been the object of my labours; and from which the topics of the day have never induced me to swerve. It is evident that this outline must be ascertained, before the functions of particular organs can be successfully investigated; all of which more or less depend on the general laws of our frame.

"The following, I believe, is the first attempt which has been made to ascertain experimentally the seat, the functions, and the nature, of all the powers of the more perfect animal, and the various relations they bear to each other, by which several, and in some functions all of these powers being enabled to co-operate, their more complicated results are effected. In the latter part of the subject, I have found much care required in rendering the language sufficiently explicit; and if in any instance I have failed in this attempt, I hope it will in some degree be ascribed to the very complicated nature of the subject, arising from the great variety of facts on which the conclusions are necessarily founded."

It will be quite obvious that so comprehensive a system of inquiries as is embraced in this paper, does not admit even of specification, to say nothing of the evidence by which Dr. Wilson Philip has supported his views, within the limits which we can allot to it here. The style of the paper, too, is such that it can hardly be abridged, and by any one not pretty well acquainted with the views of other authors, and, consequently, tolerably conversant with the subject, it would not be readily understood. It is, nevertheless, a paper of deep inquiry; and all who know the value of Dr. Philip's long-continued researches, will read his own analysis of his labours, and his matured views, with a corresponding interest. His general position is, that,

"Beside the mechanical powers, of which the living animal evidently partakes in common with inanimate nature, it possesses, we have seen, four distinct powers, apparently peculiar to itself, having no direct dependence on each other, but each depending on the other three, for the maintenance of its organs; the sensorial, the nervous, and the muscular powers, and the powers of the living blood. By these powers are maintained the two systems into which the various functions arrange themselves, the vital and sensitive systems, the object of the one being the maintenance of our bodies, of the other, our intercourse with the external world."

To establish this, and to point out what he conceives to be the seat of the different functions, and the functions of the different structures, as well as the rationale of their mutual phenomena, is the object of the paper.

XIX. *Discussion of the Magnetical Observations made by Captain Back, R.N., during his late Arctic Expedition.* *By* S. Hunter Christie, Esq., M.A., F.R.S., &c.

The extraordinary exertions made by Captain Back during his prosecution of the deeply interesting journey which he was deputed to undertake in search of the expedition of Sir John Ross, are such as to create, on their own account, a deep sympathy with him in his hazardous progress: but when we reflect upon the scientific exertions which he made, in addition to those which his immediate duties pressed upon him, we are impressed with the sense of a superior being amongst our fellow-men having been, by that event, called into the full activity of his powers. The total inadequacy of his means, the arduous nature of his immediate duties, and the urgency of his paramount objects,—combined with the nature of the observations which, under all the disadvantages created by these circumstances, he was able to make—cannot fail to excite our admiration at a degree of skill, intrepidity, and devotedness to science, such as the narratives of navigators and travellers have seldom equalled, and never can exceed.

The observations themselves were submitted to Mr. Christie for discussion, and the details of these discussions form the object of the present paper.

It is to be remarked, that Captain Back had no hypothesis to support; nor, indeed, if he had such, had he any means of computing the consequences of any set of observations which he might make. He did not attach a table of logarithms to his instrument, nor had he any formula by which to compare his results with each other. His observations were not "coaxed" into agreement, but put down as the instruments, be they good or bad, indicated. These were supplied in their original state to Mr. Christie, and by him they have been subjected to such tests as only a mathematician could apply. Amongst them, discordances are to be found; but, considering the nature of the observations, and the region in which they were made, these discordances are neither so many nor so great as we might have been led to anticipate.

Though this paper is valuable as a contribution towards the determination of terrestrial magnetic phenomena, it is of still greater value as containing methods by which the observations can be effectually used. Being, however, almost entirely mathematical, it does not admit of being analysed in popular language; and hence we must content ourselves with a general indication of its character and objects.

Mr. Christie first discusses the dip of the magnetic needle, as indicated by Captain Back at the several stations where he was able to make observations, by means of equations which he had given in a paper in the *Philosophical Transactions*, 1833; these equations being slightly modified, so as to offer greater facility in the actual computation of results. In this formula, the particular mode of structure of the needles is taken into account. From these discussions he concludes, "That we are to consider the results not only as entitled to the confidence which is generally given to those deduced from observations carefully made with good instruments, but that the differences in the last column of the table in general, fairly exhibit the amount of the error in each case, by which the result may be affected."

He next proceeds to a comparison of the observations of the dip and variation of the needle with theoretical results; and, commencing by a remark that,—

"On the hypothesis* of two magnetic poles symmetrically situated in a diameter of the earth and near to its centre, the poles of verticity and of convergence will coincide, and the tangent of the dip will be equal to twice the magnetic latitude. Although, viewing all the phenomena on the whole surface of the earth, such an hypothesis is clearly inadequate to their explanation, it is interesting to inquire how far it may be consistent with those observed on a limited portion. For such an inquiry, the observations made by Captain Back are peculiarly well adapted, since in no case has so direct a progress been made, to such an extent, towards the magnetic pole, whether we consider that point as the point of convergence of magnetic meridians, or that at which the direction of the force is vertical. Assuming then the coincidence of these points, I had proposed inquiring whether the differential of the dip and the differential of the magnetic latitude, taking the increments in observations not very distant from each other to express these differentials, had the ratio which the theory gave, and had indeed made the requisite computations and comparisons; but on further consideration it appeared to me that this comparison was not so good a test of the theory as the more direct one of the dip itself with the magnetic latitude, since small errors in the dip would become very sensible in the value of the differential, and if these errors happened to conspire at two stations, this value might be doubled or reduced one half. I do not propose in the first instance giving the detail of that comparison, but it may be proper to mention the general nature of the results."

After giving the requisite investigations, as applied to Captain Back's observations, he continues:—

"By an inspection of the numbers in the sixth column of this table, which indicate the errors of the theoretical result, it will be seen that, with very few exceptions, there is not that accordance between the observations and the theory which, for the establishment of the theory, we ought to look for; and that they rather indicate, that although the theory may be true as a first approximation, yet it requires considerable modification to render it accordant with the observations."

After a second investigation, by a modified process, the results of which are tabulated, he proceeds:—

"Although the differences here shown between the results of theory and those deduced from the observations are in some cases less than in the preceding table, yet in others they are greater; and the comparison does not upon the whole show a nearer coincidence. If this want of coincidence is to be attributed to errors in the observations, I think that the two comparisons which I have instituted indicate errors in the observed variations rather than in the dips of the needle, which have been deduced from the observations. The character of the differences between the theory and the observations, independently of their magnitude, strongly corroborates this conclusion*."

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* We have already, in the *Horæ Magneticæ*, made some observations on this subject, to which the reader is referred. The formula in question is

Tan. dip = 2 tan. magnetic latitude.

Mr. Christie then discusses the intensities of the terrestrial magnetic forces at the several stations, as reduced for the several foreign elements that enter into the observations, especially that of temperature. He here again brings under examination the theory of two poles, situated, as Biot supposed, extremely near the centre of the earth, and at equal distances from it in the same diameter. Amongst themselves, the results of Captain Back's observations are tolerably consistent with the formula; but, compared with the intensity at distant places, as London, there is discordance entirely fatal to the truth of that formula, and, consequently, to the hypothesis on which it is founded. Mr. Christie seems inclined to consider that it may be correct as a "first approximation;" and that other terms will be required to be taken in, to render it general. We must, however, recollect, that the formula in question is *accurately* the result of the hypothesis in question; and hence, that to modify the theorem, we must alter the theory. It is not a matter of mere further developement; and it is possible that, under another form of the hypothesis, we shall have an entirely new set of mathematical difficulties to grapple with. Of this, however, we hope, ere long, to offer our readers some further notice.

Mr. Christie is decidedly opposed to Hansteen's method of determining the intensity, and, we think, with good reason; not only where the dip is great, but in other cases also. In high magnetic latitudes, however, a source of difficulty of a formidable kind comes into play, which is less felt in lower latitudes,—the increased *relative* value of very extraneous local influence. Mr. Christie considers Point Ogle (lat. 68° 15′ 37″ N., long. 94° 58′ 1″ W.) to indicate a very near approach to the northern pole of verticity. After quoting Captain Back's account of the difficulty of making the observation, he remarks:—

"If we contrast the difficulty here manifest, in determining the direction of the magnetic meridian by means of needles delicately suspended, with the facility with which its direction was, apparently, determined by Sir John Ross at Victory Harbour and Padliak, at which places he states that he ascertained the dip to be 89° 55′ and 89° 56′, we cannot but conclude that such results are greatly in excess. With such a dip, all determinate direction in a horizontal needle, arising from the force of terrestrial magnetism, however delicate might be the suspension of the needle, is quite out of the question; and if a horizontal needle, so situated with respect to the pole of verticity, had a determined direction, it must have been due to the force exerted upon it by some mass in its vicinity. The dip at Victory Harbour, according to Captain James Ross's observations, is 88° 55′, and at Padliak 89° 17′; but even with this amount of dip I do not consider that the direction of the magnetic meridian could be ascertained with anything like precision, by means of a Kater's azimuth compass, however accurate might be its construction, and with whatever care it might be used. At Cape Isabella, where Captain James Ross observed the dip 89° 22′, the north point of a Kater's azimuth compass was directed to the north-west, but 'its action was uncertain to eight or ten degrees.' Captain Back remarked this sluggishness of the compass-needles from the time he quitted Rock Rapid; his own,—a small Kater's azimuth very probably, certainly one of very delicate suspension,—he remarks, 'frequently remained wherever it was placed, without evincing the slightest tendency to recover its polarity.' I have referred to these circumstances of the two expeditions, because they all tend to show, quite independently of the agreement which I have noticed among the results deduced from the observations, that at Point Ogle at least as near an approach was made to the northern pole of verticity as at Padliak or Cape Isabella; and because the observations at Rock Rapid, the last point where, probably, the direction of the magnetic meridian could be ascertained with something like precision, would assign a position to this pole different from that assigned to it by Captain James Ross. As, however, I propose on some future occasion, investigating the positions which the observations on the continent and in the archipelago of North America would assign to the poles of verticity and convergence, I shall not now pursue the subject further."

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* Mr. Christie is not singular in the belief that the variation is equally liable, if not more liable, to error in its determination than the dip. It is peculiarly the case in high magnetic latitudes; though we confess we do not place implicit reliance upon the superior accuracy of variation determinations, over those of the dip, in any region, except in some cases very near the magnetic equator. At least, we find, generally, greater discrepancies between the variations made out by different observers, than we do between the dips made by the same persons.

XX. *Inquiries concerning the Elementary Laws of Electricity. Second Series. By* W. Snow Harris, F.R.S., &c.

This paper is opened by the description of a new mode of measuring electrical intensity, which the inventor calls, from its form, the "bifile balance;" and the author proceeds to detail certain experiments made with it, and to deduce certain laws from them. As the instrument could not be adequately described without the aid of figures, nor the experiments understood without a knowledge of the instrument, we are compelled to pass it over by a simple reference. With respect to the *laws*, we have, we own, some doubt of their accuracy; though we equally own that our doubts are more founded on a seeming inconsistency with other laws which we been in the habit of considering already proved, than from any inconclusiveness in the inductions so far as we have had leisure to examine them. At any rate this paper, while it adds one more proof to the numerous ones already before us of Mr. Harris's expertness in manipulation, and his rare and elegant skill in devising philosophical instruments, will tend to call the attention of experimenters to that most important of all objects in philosophy—the determination of the relative numerical values of the *forces* which produce the phenomena of electricity and magnetism.

XXI. *Notes relative to the supposed Origin of the Deficient Rays in the Solar Spectrum; being an Account of an Experiment made at Edinburgh during the late Annular Eclipse of* 15*th May*, 1836. *By* James D. Forbes, Esq., F.R.S., L. and E., F.G.S., &c.

This paper will appear entire in an early number of this Magazine.

XXII. *A Comparison of the late Imperial Standard Troy Pound, with a Platina Copy of the same, and with other Standards of Authority. Communicated by* Professor Schumacher, For. Mem. R.S., *in a Letter to Francis Baily, Esq., V.P. and Treas. R.S.*

This paper is too important to be passed over in the slight notice which our space in this place would allow us to give; and we therefore intend to enter into a fuller account in a separate article in an early number.

XXIII. *On the Brain of the Negro, compared with that of the European and Orang-Outang. By* Dr. Frederick Tiedemann, *Professor of Anatomy and Physiology in the University of Heidelberg, and Foreign Member of the Royal Society.*

Few subjects have been treated more vaguely and inconclusively than the causes of the alleged inferiority of the negro to the Caucasian race of men, both in respect to physiological structure and mental capacity. The most degraded negro tribes have been assumed as standard specimens of the whole race; and, even with respect to these, the imperfection of organization has been assumed as a proof of mental inferiority; and this, in its turn, as a justification of the white European, in still further degrading them, both mentally and morally, by the most cruel slavery.

Notwithstanding that almost every writer on general physiology has ventured his assertions respecting the negro race, and a few accidental observations have been made on the form and magnitude of the "organ of mind," no one has fairly entered upon the investigation in such a way as to give reason to hope for any general satisfactory conclusion, before Professor Tiedemann. The general opinion had been, as is well expressed by Mr. Lawrence, that "in all the particulars just enumerated, [the characters of the Ethiopian variety of man] the negro structure approximates unequivocally to that of the monkey. It not only differs from the Caucasian model, but is distinguished from it in two respects; the intellectual faculties are reduced, the animal features enlarged and exaggerated." The extensive series of observations made by Professor Tiedemann perfectly contradict this assumption; and in order to accomplish this investigation in the most satisfactory manner, he has examined the most celebrated museums both on the Continent and in Great Britain.

The human brain is absolutely larger than that of any other animal, the whale and elephant excepted; although, relatively to the size of the body, it is exceeded by that of the sparrow and many other small singing birds, as well as several of the smaller apes. The superiority, therefore, of the human faculties is not to be sought in the relative or absolute magnitude of the brain, but in regard, also, to "the bulk and thickness of the cerebral nerves, and likewise to the degree of perfection in its structure." From his researches, Dr. Tiedemann draws the following conclusions:—

"1. The brain of a new-born child is relatively to the size of the body the largest: the proportion is 1 : 6.

"2. The human brain is smaller in comparison to the body the nearer man approaches to his full growth. In the second year the proportion of the brain to the body is as 1 : 14; in the third, 1 : 18; in the fifteenth, 1 : 24. In a full-grown man between the age of twenty and seventy years, as 1 : 35 to 45. In lean persons the proportion is often as 1 : 22 to 27; in stout persons as 1 : 50 to 100, and more.

"3. Although Aristotle has remarked that the female brain is absolutely smaller than the male, it is nevertheless not relatively smaller compared with the body; for the female body is in general lighter than that of the male. The female brain is for the most part even larger than the male, compared with the size of the body.

"The different degree of susceptibility and sensibility of the nervous system seems to depend on the relative size of the brain as compared with that of the body. Children and young people are more susceptible, irritable, and sensible than adults, and have a relatively larger brain. Thin persons are more susceptible than stout. In diseases which affect the nourishment of the body the susceptibility increases as the patients grow thinner. The susceptibility and sensibility decreases, on the other hand, with persons recovering from a long illness, gradually as they regain their strength. The degree of sensibility in animals is also in proportion to the size of the brain. Mammalia and birds have a larger brain and are more susceptible than amphibious animals and fishes. I propose to go into this subject on another occasion, as it would at present take me too far from my immediate object."

Very few observations have been actually made of the actual and relative weight of the brain of the negro; and Dr. Tiedemann has, therefore, had recourse to ascertaining the relative contents of the cavity of the skull; and he gives tables of the results obtained from a number of negro, European, Mongolian, American, and Malayan skulls, thus examined. The general conclusion is, that the cavum cranii of the negro is not relatively smaller than that of the European and other human races.

He then proceeds to show, on the authority of the most intelligent and accurate travellers in Africa, that the general characters and marks of the Ethiopian race usually given, apply only to a very small, and the most depraved of all the negro tribes, as they have been morally, and thence physically, debased by intercourse with the whites,—those on the coast, and their descendants in slavery.

"These characters are, the skin black; the hair black and woolly; the skull compressed laterally; the forehead low, depressed, slanting, and narrow; the cavity of the cranium smaller, and reduced both in its circumference and inits transverse diameters; the eyes prominent; great developement of the face, and projection towards its lower part; the cheekbones prominent; the jaws narrow; the superior incisor teeth oblique; the chin retracted; the nose broad, thick, and flat; the lips, particularly the upper one, thick and projecting. This is the countenance of the Mozambique and Guinea negroes, but it is not the feature of the natives of the high lands of Africa. The truth of this assertion is fully attested by the latest African travellers. Winterbottom says of the tribes of Timmanu and Soosoo negroes, in the mountainous districts of Sierra Leone: 'The sloping contracted forehead, small eyes, depressed nose, thick lips, and projecting jaws, with which the African is usually caricatured, are by no means constant traits; on the contrary, every gradation of countenance may be met with, from the disgusting picture too commonly drawn of them, to the finest set of European features.'

"Tuckey says the same of the Jalaffs or Oualafs; Meredith of the Fantees; Adams and Bowdich of the Ashantees, the Dahomeys, and the *negroes of the* banks of the river Chamba: they have good features, neither broad nor flat noses, nor thick lips. The Mandingos on the banks of the rivers Gambia, Joliba, the higher Senegal, and Niger, as also the Foulahs or Fullahs, and Fellatahs in the interior of Africa, in Bondu, Timboctoo, Housan, Sudan, Bornoo, and Kaschna, vary but little, according to Mungo Park, Denham, and Clapperton, excepting in colour, from the Europeans. Their skin is not so black as that of the negroes on the coast of Guinea, and their black hair is not so woolly, but long, soft, and silky. They have neither broad flat noses, thick lips, nor prominent cheekbones; sloping contracted forehead, nor a skull compressed from both sides, which most naturalists consider as the universal characteristics of a negro. Most of them have well-formed skulls, long faces, handsome, even Roman or aquiline noses, thin lips, and agreeable features. The negresses of these nations are as finely formed as the men, and are, with the exception of their colour, as handsome as European women.

"Somerville, Barrow, Lichtenstein, and Burchell, have shown that the Caffres and Bachapins, or Betchuanas, have the same form of skull, and the same high forehead and prominent nose as Europeans. Credible travellers and accurate observers confirm also what the celebrated Blumenbach said thirty years back, 'that the exterior of negroes gradually approaches to that of other races, and acquires by degrees their fine features.'"

The author then examines the spinal cord and medulla oblongata in the European and negro subject, and finds no remarkable difference, except that which arises from the different size of the bodies he examined. He afterwards examines the cerebellum of the negro, which he finds, with regard to outward form, fissures, and lobes, to be exactly similar to the European. The cerebrum is next examined. The general external character was the same as in the Caucasan; the differences being chiefly in the greater or less developement of some particular portion of the structure, probably not greater in any case than may be found amongst Europeans themselves; and in the internal structure he did not observe any difference so as to render special description of the negro necessary or desirable.

The next question examined is, whether the nerves of the negro are thicker than those of the European, or, in other words, the brain less in comparison with the quantity of nerve? This he decides in the negative.

Lastly, his inquiries are directed to the question, "Has the brain of the negro more resemblance to the Orang-Outang than to that of the European?" He finds the following results:—

"1. The brain is absolutely and relatively smaller and lighter, shorter, narrower, and lower than the human brain.

"2. The brain is smaller in comparison to the size of the nerves than in man.

"3. The hemispheres of the brain are, relatively to the spinal marrow, medulla oblongata, the cerebellum, corpora quadrigemina, the thalami optici, and corpora striata, smaller than in man.

"4. The gyri and sulci of the brain are not so numerous as in man.

"The hypophysis and the origin of several nerves are wanting. By comparing the negro brain with those of the orang-outang, we shall find the same difference as between the brain of the European and the orang-outang. The only similarity between the brain of the negro and that of the orang-outang is, that the gyri and sulci on both hemispheres are more symmetrical than in the brain of the European. It remains, however, to be proved whether this symmetry is to be found in all negro brains, which I very much doubt. The size and quantity of the brain of the negro varies as much as the European from that of the orang-outang. I measured the capacity of the cavum cranii of a full-grown Asiatic pongo, and found that it only held 11 oz. 7 dr. The brain of this pongo was therefore much smaller than is usual, even in congenital idiotism."

His remarks on the intellectual characters of the Ethiopian race are worthy of the attention of every man who has a single grain of philanthropy in his bosom, or of science in his mind. It is at length made evident that the views which have been entertained by those who advocated the amelioration of the negro race, as to their capability of civilization and of intellectual and moral culture, are borne out by the structure and character of the "organ of mind;" and we trust the labours of Professor Tiedemann will have some influence on even our transatlantic brethren, as well as upon the conduct of the European governments generally. Those who advocate negro slavery, either in opinion or in practice, have now not a single argument left them, save the demonlike one, that "might is right."

XXIV. *On the Respiration of Insects. By* George Newport, Esq., *Member of the Royal College of Surgeons, and of the Entomological Society of London. Communicated by* P. M. Roget, M.D., Sec. R.S.

This paper, the relative value of which has been the subject of some discussion, it being that to which the Royal medal was last year awarded, is no doubt a paper of considerable merit; though it is affirmed that the greater part of Mr. Newport's experiments and conclusions had been anticipated by Müller, and other German naturalists.

Mr. Newport commences by a description of the parts of the insect concerned in respiration; viz., the tracheæ, the spiracles, the muscles, the nerves: and then proceeds to the rationale of respiration, the quantity of respiration, and the duration of life in different media, of different insects. The paper of Mr. Newport is a very interesting one, and even if it be the fact that Müller had anticipated him (which we very much doubt), the inquiries are equally new to English readers, and deserving of deep attention from every cultivator of natural science.

XXV. *On the Connexion of the Anterior Columns of the Spinal Cord with the Cerebellum. By* Samuel Solly, Esq., *Lecturer on Anatomy and Physiology at St. Thomas's Hospital. Communicated by* P. M. Roget, M.D., Sec. R.S.

This paper being entirely on a subject of minute and delicate anatomy, could be of little interest to our readers; whilst to those who are interested in the subject, either as to the anatomy or the physiological discussion to which it is subservient, no abbreviated account of so short a paper could be of material use. We, therefore, pass it over, merely indicating its existence.

XXVI. *On the Temperatures and Geological relations of certain Hot Springs, particularly those of the Pyrenees; and on the Verification of Thermometers. By* James D. Forbes, Esq., F.R.S., *Professor of Natural Philosophy in the University of Edinburgh.*

During the Summer vacation of the University, in 1835, Professor Forbes made a tour of the Pyrenees, for the special purpose of examining the hot springs of that region, which were known to be very abundant; and the results of his researches are given in the present paper, with considerable attention to all the circumstances which can affect the inquiry, so far as at present known. After detailing the mode employed in verifying his thermometers, Professor Forbes describes, in each case, the geological position, the specialities of the several springs, and their temperatures.

These springs generally rise at the junction of the granite with the limestone, and in all cases where they do not, it is in the midst of distinct traces of volcanic energy, by which the general relation has been violently destroyed. Many interesting geological phenomena are detailed, but of which no abridged account could be given. Professor Forbes has tabulated the results of his observations on temperature, both in the Pyrenees and in other parts of Europe. With this, premising his notation for explaining one or two other circumstances, we must close our notice of his invaluable paper, and, with it, of the volume of the *Transactions* itself. They altogether amount to sixty-two springs.

The relative magnitudes of the springs are denoted by the numerals 1, 2, 3, 4, 5, the highest numbers being applied to only two springs, whose discharge is quite enormous. The prefix ‡ is applied to those springs which seem best adapted to determine the general question of constancy of temperature, and * to those which, from passing through long pipes, or for other reasons, are of little value.

PYRENEES.

No.	Place.	Spring.	Vol.	J. D. F. 1835.	
				Fahr.	Cent.
* 1.	Eaux Chaudes (2200 ft. above sea)	Esquirette	?	91°·4	33°·0
* 2.	———	Clot...............	?	94·6	34·7
* 3.	———	Rey	?	92·0	33·3
4.	———	Arresecq (A)......	1	76·3	24·6
5.	———	——— (B)......	1	76·2	24·5
6.	———	Baudot	1	80·2	26·7
7.	Eaux Bonnes (2600 feet)...........	Source Vieille ...	1	91·4	33·0
8.	———	S. de la Montagne	1	54·4	12·4
9.	Cauteretz (3100 feet)	La Poze	2	110·3	43·5
10.	———	Nouvelle Poze ...	2	113·5	45·3
11.	———	César	2	118·1	47·8
‡12.	———	Raillière	3	101·9	38·8
13.	———	Petit St. Sauveur	2	90·6	32·5
‡14.	———	Mahourat	2	121·7	49·8
‡15.	———	S. des Oeufs	2	130·1	54·5
16.	———	Bois	2	112·3	44·6
17.	St. Sauveur (2500 feet)	La Hontalade ...	2	68·5	20·3
‡18.	Barèges (4200 feet)	Grande Douche	3	111·9	44·4
19.	———	L'Entrée	?	104·4	40·2
20.	———	La Chapelle	?	88·7	31·5
21.	———	Polard	2	98·3	36·8
‡22.	Bagnères (1800)	Dauphin	4	119·0	48·3
‡23.	———	La Reine	4	114·0	45·6
24.	———	Roc de Lanne ...	2	115·0	46·3
*25.	———	S. des Yeux	1	89·4	31·9

No.	Place.	Spring.	Vol.	J. D. F. 1835.	
				Fahr.	Cent.
26.	Bagnères (1800 feet)	St. Roch	1	109°·4	43°·0
27.	———	Foulon	2	93·2	34·0
28.	Bagnères de Luchon (2000 feet)	La Reine	2	110·6	43·6
29.	———	Grotte Supérieure	2	139·1	59·5
*30.	Lez	A	very small	86·4	30·2
*31.	———	B		82·9	28·3
‡32.	Ax (2500 feet)	S. des Canons ...	4	168·0	75·6
33.	———	S. des Rossignols	2	161·2	71·8
34.	———	L'Etuve	2	151·0	66·1
‡35.	Las Escaldas (about 4700 feet) ...	Colomer. Source	5	107·0	41·7
36.	———	Buvette	2	107·1	41·7
37.	———	Merlat. Douche	1	90·7	32·6
38.	———	Grande S.	2	90·9	32·7
39.	———	Margail	2	91·9	33·3
‡40.	Dorres (4700 feet)	Dorres	3	104·4	40·2
41.	Thuez (about 2700 feet)	Source A	2	171·5	77·5
42.	———	B. S. du Bord de la Tet	3	165·0	73.9
43.	Vernet (about 1700 feet)	A. Intérieure......	2	132·2	55·7
44.	———	B.	2	124·1	51·2
*45.	———	Source de 1835 ...	?	118·8	48·2
‡46.	Arles (900 feet)	Gros Escaldadou	5	139·0	59·4
47.	———	Petit Escaldadou	2	145·3	62·9
48.	———	Manjolet	1	109·3	42·9
49.	———	Gourg-Negre ...	2	140·0	60·0
	MONTS-DOR.				
‡50.	Bains du Mont-Dor (3400 feet)...	César	3	108·0	42·2
51.	———	Grand Bain, hottest part...	2	107·9	42·2
52.	———	Ramond............	2	107·1	41·7
53.	———	Rigny	2	108·1	42·3
‡54.	———	Madelaine	4	110·9	43·8
‡55.	Bourboule (2800 feet)	Grand Source ...	2	121·2	49·6
	SCHWARZ-WALD; ALPS.			1832.	
56.	Baden-Baden	Principal Spring	?	147·4	64·1
57.	Leuk (4700 feet)	....	3?	123·1	50·6
58.	Pfeffers (2300 feet)	....	3	97·9	36·6
	ITALY.			1826.	
‡59.	Baths of Nero (30 feet)	....	?	182·2	83·4
60.	La Pisciarella, near Lago d'Agnano	....	?	112·0	44·4
				1827.	
61.	Spring at Temple of Serapis at Pozzuoli	....	?	98·5	36·9
62.	Ischia	Gurgitella	?	149·	65·0

ON OPTICAL ILLUSIONS.

No. I.

It would be a curious inquiry, and one fruitful in valuable information, to investigate the instances in which, and the causes by which, natural objects appear to be what they are not. It would lead to many remarkable results, and would serve to furnish some evidence of the manner in which our notions of form and configuration originate. We wish to draw the attention of those readers who have but recently entered on the study of science, to this subject, assuring them, at the outset, that they will be amply repaid for the time employed in the inquiry,

If we analyse our notions of form and figure, we shall find that we depend almost entirely on the kind and degree of light which is reflected to the eye from any object under consideration If we have, for instance, a marble bust, and a chalk or Indian ink drawing of the same individual, how do we know, without *touching* them, (for that is a species of evidence which we exclude from the present inquiry,) that one is a raised bulk, while the other is a flat surface? Simply from the degree of light which comes to the eye from the different parts of the object. We know—experience has taught us—that every projection or elevation reflects more light from that side which is nearest to a window, or to a lighted candle, than from the other side; and upon placing one of the objects above alluded to in different positions with regard to the window, if we find that the dark side of every elevation in the face is *from* the window, we immediately conclude that that is the bust and not the drawing; but if we find that, when we place it at one side of the room, the shaded part of the nose, for instance, is *towards* the window, but that when it is on the other side of the room the shaded part is *from* the window, we immediately conclude, without placing the hand on either object, that we are looking at the drawing, and not at the bust. And this would be the case if the drawing were coloured precisely to imitate the bust. This is a circumstance which should always be attended to in placing a portrait in a room; if the *painted* shadows do not correspond with the positions of the *real* shadows on that side of the room, the illusion is greatly lessened.

These remarks apply to *elevations* above the common surface of an object, but our notions of *depression* are formed exactly in a similar way. We should find that, if we could change the appearance of every spot in a raised object from light to dark and from dark to light respectively, the mind would at once determine that we were then looking at a *depressed* or *hollow* cavity, the exact type of the raised object which we were before regarding; we should find that no other element would be called for in fixing our ideas.

Sir David Brewster has beautifully illustrated this singular fact in his *Letters on Natural Magic*, by referring to the effect produced on the appearance of an intaglio[*], or a cameo[†], when viewed through a microscope, or any assemblage of lenses which *inverts* the object.

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[*] An Italian word, signifying an engraving.

[†] The origin of this word is very doubtful.

If a common seal, or intaglio, be held near a window, the parts *farthest* from the window receive most light; while, if the cast or impression produced from that seal be similarly viewed, the parts *nearest* the window will receive most light, and it is in that way that we immediately know the elevated from the depressed image.

Now, the effect of viewing this same seal through a microscope, is to invert the position of the object; and consequently, if we confine our attention to any given depressed point of the seal, we should find that the light and the dark sides of that depression had *changed places*, and the shaded side of every little elevation and depression would be exactly in the same position as if we were viewing a *cast* of the seal without a microscope.

It will even be found that a very slight effort of the mind will be sufficient to produce this effect without any lenses whatever: suppose an an intaglio be viewed at night, with a candle at the *left* of the observer; let him then *fancy* that the candle is on his *right* hand, and the idea that he is viewing a cameo will immediately impress itself on his mind. That the direction of the shadow is the real evidence on which we form our opinion as to the character of the surface which we are viewing, is further borne out by this fact: that if we hold an intaglio and a cameo exactly *opposite* to the source of illumination, it is difficult to distinguish one from the other, as both sides of every elevation or depression are nearly equally illuminated.

If we consider for a moment, in what way we distinguish a concave from a convex surface, we shall find that it merely consists in a different distribution of light and shade; those parts which are light in the one, being shaded in the other, and *vice versâ;* the deception produced in objects of this form, by inverting the position of the image, is most striking, and affords one of the best instances of the fallacy of our reasoning, when we lose one of the data on which we ground our inferences.

If we take any bright convex or concave surface, no matter what the material, and place it between the window and the eye, so that the eye sees it by looking *downwards* at an angle of from 20° to 60°, there is a certain distribution of light and shade on the object, which enables the eye, from habit, to determine whether it be convex or concave; if we can now invert the position of the edges of the object, with reference to the eye and the window, the shaded parts assume just the position which would be assumed by the opposite curvature; now, this inversion may be done without any lenses whatever.

Take a common Wedgwood-ware evaporating-dish, or a common tea-saucer, a basin, or any object which is concave on one side and concave on the other—a watch-glass even will do,—and place it on a table between the observer and the window, with the concave side upwards; then hold a piece of common glass (with the under side blackened) in such a position that an image of the object will be reflected from its surface to the eye: the laws of optical reflection teach us that the rays from the farther edge and those from the nearer edge cross each other in their passage to the eye, and assume an inverted position; it will now be seen that the object has every appearance of being a convex surface, and if the angle of observation be well chosen, (which depends partly on the height of the window,) the illusion is so strong that it can scarcely be removed from the mind. If a convex mirror be substituted, and its position well adjusted, the distortion will present all the appearance of a concave mirror.

It is not essential to this experiment that the reflector should be black on its under surface, although it is more favourable for the purpose; any polished surface will suffice, provided it receives the rays at a large angle of incidence: it can be seen very well by reflection from one of the faces of a prism, and a singular effect is produced by a particular adjustment of the prism, by which two images of the same object may be conveyed to the eye within a short distance of each other; one is the regular refracted and transmitted image, and the other a reflection from one of the *internal* faces of the prism: one of these images will be convex, and the other concave, and their juxtaposition forms a very remarkable appearance—one being prismatically coloured and *convex*, and the other of its natural colour and *concave*.

If the student in optics carefully considers the law that "the angles of incidence and reflection are always equal," and will carry out that principle to its fullest extent, he will find that every one of the phenomena of which we have been treating depends solely on the operation of that law; if he considers the position of the source of illumination, the degree of curvature of the surface on which any ray falls, and the angle at which the eye receives the reflection, he can clearly show that that law determines what part of the object will appear bright and what part shaded.

The same law determines the production of another phenomenon, as remarkable and much more beautiful than the former; if we take a plate of looking-glass, and sprinkle a few grains of dust upon it, and view it perpendicularly with one eye at a few inches distance, the dust appears arranged in a most beautiful radiating star, of which the eye is the centre; it matters not how unequally it is scattered; the symmetry is invariable.

Now in such a case as this, before we begin to *theorize*, it is proper to extend the experiment to other objects, and in accordance with this, it will be found that if the object be a polished surface of steel, of silver, of mercury, or any substance but silvered glass, no such radiating appearance presents itself; if now the student reverts to the law above alluded to, he will at once detect the cause; when the dust is scattered on the surface of silvered glass, an image of each little particle is reflected from the *mercurial surface* through the glass again to the eye; as the angle at which we view any particle increases, so must the apparent distance between it and its image increase, until we arrive at 45°, which gives the maximum of distance.

Now the particle and its reflected image are in the same vertical plane which passes through the eye and the image of the eye; the particle, its image, and the image of the pupil of the eye appear, therefore, to be in the same right line, and as the same applies to every particle, as the line which joins the particle and its image would pass, if produced, through the image of the pupil of the eye, wherever the particle be placed, the pupil appears to be a nucleus or centre from which all these double images extend radially outwards.

When, however, a polished metal is used, there is no reflecting surface from which a *second* image can be obtained, and we therefore see the particles themselves, unaccompanied by any reflected image, and the symmetrical appearance is not then produced. The employment of a concave mirror affords an excellent proof that this beautiful radiating appearance is the effect of reflection. If we hold the eye at the focus of the mirror—that is, at the centre of the sphere of which the mirror is a section,—we see none of these radial lines, but as we approach near to the mirror, they gradually develope themselves; this arises from the circumstance, that when the eye is at the centre of the sphericity, incidence and reflection are both perpendicular to the mirror, or rather, the reflected image is concealed by the particle itself, and therefore cannot reach the eye; but when we approach nearer, the images of the *lateral* particles become visible, and the starry effect begins to appear.

In a *convex* mirror, the effect is very beautiful, on account of the increased obliquity which its curvature gives to the incident ray, and the non-existence of a focal point in front of the mirror.

The effect is greatly heightened by mixing powders of two different colours—red and green, or blue and orange, for instance,—as those colours which are complementary to each other produce a singularly pleasing effect by their juxtaposition. A very slight sprinkling of milk, or any coloured liquid, likewise produces this symmetrical effect.

Instead of using glass, we may use two fluids of different densities and different refractive powers, but the two which best answer the purpose are water and mercury; if a little powder be sprinkled on the water, it will be reflected from the mercury under the water, and the same effect produced as with glass, but the latter is the more convenient of the two.

If the eye be directed to one *corner* of the glass, the particles will have the appearance of an expanded fan, emanating from that corner.

Thus may the same simple law be brought to bear upon the whole of the appearances which we have now detailed: in all these instances an object, or an assemblage of objects, *appear* to be what they are not, simply from our neglecting to seek for an explanation from the only sources to which we should apply in such cases, viz. the unerring laws of Nature, the simplicity of which is as conspicuous as their beauty and their universal application.

T.

SIMULTANEOUS METEOROLOGY.—No. III.

TABLE of HOURLY METEOROLOGICAL OBSERVATIONS, made during the 21st and 22nd Sept., 1837, at Blackheath Road, near Greenwich, about four miles and a half S.E. of London, *by and under the superintendence* of J. H. Belville, in conformity with the Instructions circulated by the South African Literary and Philosophical Institution.

DATE.	HOUR.	BARO-METER.	THERM^R Attached.	THERM^R In open air.	WIND. Direction.	WIND. Strength.	Prop. of Cloud.	STATE OF THE ATMOSPHERE, CLOUDS, &c.
		Eng. In.	Fah °	Fahr. °				
Thursday, September 21, 1837.	VI. A.M.	29·950	68	51·0	E.	0	5	*Stratus.* Clear in zenith. (Ther. min. at night, 50·6°.)
	VII.	29·950	68	55·7	E.	0	4	*Stratus* into *Scud.* Sun appears.
	VIII.	29·953	68	57·4	E.	1	9	Sky now covered with fresh *scud* from E.
	IX.	29·958	68	60·0	E.	1	7	*Scud* disperses fast—perfect blue sky.
	X.	29·970	69	62·5	E.	1	3	Clear. A few light *cumuli* scattered to the N.
	XI.	29·972	72	64·0	E.	1	0	Cloudless.
	XII.	29·980	73	65·0	E.	2	0	Ditto.
	I. P.M.	29·980	74	66·0	N.E.	2	1	Ditto.
	II.	29·997	75	65·9	E.	2	0	Ditto.
	III.	29·999	75	65·6	E.	2	0	Ditto.
	IV.	30·000	74	64·0	E.	2	0	Ditto.
	V.	30·018	73	61·9	E.	1	1	A few light masses of *scud* coming up from the E.
	VI.	30·026	71	59·6	E.	1	3	Several groups of low *scud* have passed since the last observation.
	VII.	30·050	70	56·4	E.	1	1	Clouds nearly dispersed. *Dew falls in abundance.*
	VIII.	30·053	69	56·0	E.	0	0	Quite starlight. Cloudless.
	IX.	30·054	69	54·9	E.	0	0	The same. N.B. A delicate radiating thermom. on the ground marked 51° at 9 P.M.
	X.	30·056	69	54·0	E.	1	0	The same.
	XI.	30·057	69	53.0	E.	0	0	The same.
	XII.	30·059	69	52·5	E.	0	3	Appearances of fog and mist to southw.
Friday, September 22.	I. A.M.	30·059	69	52·0	E.	0	5	Mist. *Stratus* covers the sky.
	II.	30·058	68	50·6	E.	0	10	Dense dripping mist. Moon invisible.
	III.	30·058	68	52·0	E.	0	10	The same.
	IV.	30·059	68	53·0	E.	0	10	The same. N.B. The *minimum*, by a self-registering therm., 48·9°.
	V.	30·059	68	53·7	E.	0	10	Mist thinner. *Stratus broken in zenith.*
	VI.	30·062	68	54·1	N.E.	0	9	*Stratus* has now become more dense.
	VII.	30·081	68	55·0	E.N.E.	0	7	*Stratus* disperses. Sun shines at intervals.
	VIII.	30·093	68	58·5	E.	1	4	*Scud* moves swiftly from the E.
	IX.	30·102	68	61·0	E.	1	5	No alteration since the last observation.
	X.	30·102	69	62·0	E.	2	5	The same. *A brisk breeze.*
	XI.	30·102	71	63·5	E.N.E.	2	4	*Scud* decidedly receding.
	XII.	30·103	72	64·5	E.N.E.	2	3	Nearly cloudless. Brilliant sunshine.
	I. P.M.	30·100	74	65·3	E.	2	2	The same.
	II.	30·096	74	64·8	E.	2	1	The same.
	III.	30·100	74	64·0	E.	2	1	The same.
	IV.	30·098	73	62·7	E.	2	1	The same.
	V.	30·097	72	61·9	E.	2	0	The same.
	VI.	30·098	71	59·2	E.	2	0	The same.

Notes.—A copious dew before sunrise on the 21st. Soon after midnight on the 22nd, a dense fog prevailed for about three hours. The two days nearly clear, with brilliant sunshine, and a brisk breeze from the east. No other modification of cloud than *stratus* and *scud.* A remarkably fine period.

The time was taken from a good clock, keeping mean time. Rate scarcely perceptible during the observation. Error obtained by observation of the ball-drop of the Royal Observatory, Greenwich.

The Barometer has an elevation of 46 feet above *mean high-water mark* of the river Thames, carefully deduced by very accurate barometrical measurement. Makers, Watkins and Hill, London. The index error of scale presumed to be within a *hundredth* or two of the truth. The Thermometer, by Dollond, suspended in open air, at an elevation of 40 feet from the ground: aspect, northerly.

The comparative strength of wind is indicated by the figures thus,—0 means no wind perceptible; 1, very light breeze; 2, strong breeze. In the column headed *Proportion of* Cloud, 0, signifies quite clear. 10, no blue sky visible; 5, sky half covered.

THE BRITISH ASSOCIATION.

The Seventh meeting of the British Association for the Advancement of Science, which took place between the 11th and the 16th of September at Liverpool, was, in many points, fully equal in interest to any which have preceded it. Assembling, for the second time, in a great commercial town, and one, too, the interests of which are peculiarly identified with the progress of scientific acquirement, the Association expected, and certainly found, the utmost alacrity and kindness among all classes of the inhabitants, in furthering the objects which it had met to promote. The first meeting of the general committee was held on Saturday, September 9th, the Marquis of Northampton, President for the last year, in the chair; when some necessary changes were made in the officers. It was reported that the council had obtained the consent of the Government to a repeal of the duty on the importation of philosophical instruments, and to the extension of the Ordnance Survey to Scotland. They had also directed their attention to the establishment of a law of universal copyright, and had communicated on this subject with M. Guizot and Mr. Sergeant Talfourd. After arranging some changes in the constitution of their own body, and appointing Sectional officers, &c., the committee adjourned.

The Sections met at eleven o'clock on Monday the 11th, four of them, Mathematics and Physics, Chemistry and Mineralogy, Geology and Geography, and Mechanical Science, at the Mechanics' Institute; the Section for Zoology and Botany at the Royal Institution; that of Medical Science at the Medical Institution; and that of Statistics at the Savings' Bank. We proceed to give abstracts of the most important proceedings in each, dwelling principally on those more intimately connected with the immediate objects of our Magazine. In those Sections where the subjects admitted of a classification, they have been arranged in their natural, rather than their chronological order.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President.—Sir D. Brewster.

Vice-Presidents.—Mr. Lubbock, Mr. Baily, Rev. G. Peacock.

Secretaries.—Rev. Professor Powell, Professor Stevelly, Mr. W. S. Harris.

Committee.—Rev. Dr. Robinson, Sir W. Hamilton, Professor Christie, Rev. W. Whewell, Professor Lloyd, Professor De La Rive, Professor Plateau, Professor Henry (of New Jersey Coll.), Dr. Faraday, Professor Wheatstone, Dr. Ritchie, Major Sabine, Rev. Dr. Hincks, Mr. Russell, Professor Moll, Captain Ross, Mr. R. W. Fox, Professor M'Cullagh, Professor Challis, Mr. J. H. Abram, Professor J. S. Bagge (of Stockholm), Rev. Mr. Dawes, Mr. Dollond, Mr. Hopkins.

The first communication read to the section was entitled *Suggestions as to the probable Causes of the Aërial Currents in the Temperate Zones*, by Mr. W. R. Birt, which proceeded on the hypothesis that currents were produced in different directions on each side of the tropics, by the escape of the heated air from the regions between them towards the poles, which currents, since the sun is vertical to a spot which in *twenty-four* hours passes over a parallel of the torrid zone, must necessarily be very diversified and numerous, and must assume very different directions with regard to a place within the temperate zones. Each of them, except that from the south, would be a tangent to a parallel of latitude, and would be, in that parallel, an easterly or westerly wind, according to its direction. Mr. Birt supposed these currents to be observable near the 30th parallel of north latitude, for the north temperate zone, and traced the progress of those which originated between two hours east and two hours west longitude, to their arrival in London as S.E. S. and S.W. winds, varying through W. and N. to N.E. The change of the wind in this order he called direct, the S.W. winds prevailing more in consequence of their having a less space to traverse than the northern currents. The westerly winds were produced between four and five hours west long., the N.W. at 10th meridian west of Greenwich, the N. at 180° of longitude, the N.E. at 10th meridian east of Greenwich, the easterly between four and five hours. There was a retrograde variation also from W. through E. towards N., arising from England being subjected to the currents from the poles towards the equator to fill up the place of the ascending heated air. His observations had shown the great regularity of the equatorial and polar currents, and that their alternations were governed by fixed and observable laws.

Of the paper by Colonel Gold *on Telegraphic Communication by Electricity*, it is not necessary to enter into any lengthened detail. The public are already aware that extensive experiments are already in progress with a view of applying electro-magnetism to the propagation of signals. Colonel Gold preferred it to communication either by sound or projectiles, and mentioned with what extreme rapidity information might be conveyed by it.

Mr. Cunningham of Cork forwarded to the section a paper on the *Construction of Magnets*, in which he strongly advocated the superiority of cast iron as applied to this purpose over steel, and expressed a belief that by heating the castings red hot, and cooling them very slowly, a great improvement might be effected. Mr. Knight had recommended common blister steel, of open grain, and highly carbonised, of a size exactly suited to that of the magnets, to prevent the necessity of hammering except at the centre of the rod. It would be better that the iron should be given the proper form before it was converted into steel, and he had found that cast iron magnets were both in absorption and retention of influence superior to any other he had used. In the conversation that ensued on this subject, much doubt was expressed as to the superior value of cast iron magnets, especially whether bars of that material, if removed from their upright positions, would long retain any considerable degree of polarity. The Rev. Mr. Scoresby had recommended evenly tempered steel of the blue temper. Mr. Holden agreed in this opinion. Captain Kater, it was stated, had not recommended cast iron, and Mr. Snow Harris preferred hardened steel wire, such as is bought in the shops, as the best material for the permanent retention of magnetism, while Professor Henry mentioned that he had found cast iron inferior to common steel.

Mr. Lubbock brought forward an account of the *Discussion of Observations on the Tides*, for which more than one grant of money had been made by the Association. Mr. Jones had examined 13,391 observations made in Liverpool during nineteen years, and Mr. Russell had employed 24,592 observations of the London Docks, and the agreement between the averages obtained was very close indeed. First, with respect to the parallax inequality for the interval. Mr. Russell had combined all the results so as to obtain for each place the inequality in the interval and height for horizontal parallax 54°. The Liverpool observations made the curves deduced for the interval almost identical with those given by theory. At London, the observed time was half an hour later than the calculated time. With respect to the height, the observed curves differed more from those derived from theory. One curious result of comparing the two series of observations with respect to the diurnal inequality for the same tide was, that the order of their inequality was completely reversed. The agreement of the phenomena with Bernoulli's theory was very exact, and the diagrams exhibited by Mr. Russell showed a wonderful coincidence between the curves of theory and observation. Still extreme accuracy was not attainable. It was found from an old register that the establishment for the port of London had varied since the thirteenth century between two and three hours. Mr. Lubbock concluded by mentioning that the section had received the printed Brest tide observations from 1807 to 1835 inclusive.

Mr. Whewell's observations nearly coincided with Mr. Lubbock's. He was satisfied that the diurnal inequality was very different at different parts of the same coast, and was sometimes absolutely inverted. The rate of progress of the diurnal tide was very similar to that of the semi-diurnal. Single day-tides he believed to be only extreme cases of great diurnal inequality. Several tidal anomalies referring to the coast of Ireland, the Isle of Wight, &c. were mentioned, and Mr. Whewell then made some observations on the subject of his *Anemometer*, in which a set of small windmill vanes, or window ventilators, were presented to the wind by a common vane, and moved by the current of air in its passage; the motion being reduced by wheels and pinions, was communicated to a vertical pencil pressing against an upright cylinder, the pencil descending only the twentieth of an inch by 10,000 revolutions of the fly. The mean direction, the velocity of the wind, and the length of time it blew in each direction, were ascertained by the line traced by the pencil (the surface of the cylinder being japanned white), and hence the integral effects of the wind could be obtained. Several anemometers on this principle had been erected.

Mr. Osler of Birmingham gave an account of an *Anemometer and Rain Gauge* constructed by him, of which Mr. Whewell spoke highly, especially of the method of showing, in one diagram, so many meteorological phenomena, including, we believe, the direction and force of the wind, the quantity of rain which may have fallen, the time occupied in falling, and the state of the thermometer. Professor Lloyd said the integral force of the wind might be very easily given by it.

Professor Powell had been engaged in comparing observation and theory as regarded the *Dispersion of Light*, the agreement between them being close in bodies whose dispersion is not great, but increasing in highly dispersive bodies. The results corroborated the theory of Mr.

Kelland, a simplification of Cauchy's, by which the most extreme case now known was shown to coincide with the formulæ of dispersion, but the subject was still far from being satisfactorily investigated.

On Tuesday, Dr. Robertson opened the proceedings by reading his report on *Nutation*, comparing the results of the observations made at Greenwich with several theories of nutation, and accounting for the differences observable in the comparison. Dr. Robertson brought forward a series of calculations upon this subject, which coincided remarkably with those of Bradley.

Mr. Russell next read a report on *Waves*, investigating the influence of the form of the channel on the tidal wave, and the mechanism of its propagation. Several experiments had been made on this subject both in the Dee and the Clyde, in the latter of which the height of the tidal wave was greatly influenced by the direction of the wind. The practical results of Mr. Russell's remarks will be found at full length in our report of the Section of Mechanical Science, where the subject was brought forward in a slightly different form. When he had concluded, a discussion arose on the phenomena of waves of a character similar to that of tidal waves.

After the reading of a paper by Mr. Blackburne on *Geometrical Theorems*,

Professor Powell brought forward some remarks on the absorption of light, and what he termed the *capricious phenomena* exhibited therein, to account for which various theories had been brought forward. Von Wrede had supported the opinion that different rays might be retarded in their passage through certain media, and then coming out superposited upon other rays, might form complex rays. Professor Powell highly approved of this theory, which only required some numerical law for the facts. The chairman expressed his dissent from Von Wrede's theory.

Sir William Hamilton read a paper on the possibility of resolving equations of the fifth degree, in which he took Abel's theory as a text, though it could not be considered perfectly satisfactory.

Mr. Henwood communicated the results of a number of experiments showing that, at the same depth, the temperature of granite was considerably lower than that of slate. Some other experiments were mentioned, which gave a different result, and the Section adjourned.

On Wednesday, Professor Lloyd opened the proceedings, by a communication on a *Magnetic Observatory* in progress of erection at the expense of Trinity College, Dublin. The material chosen was argillaceous limestone, it having been thought right to reject bricks on account of their magnetic properties. The locks, hinges, &c., were proposed to be of copper, a material which was objected to by several members, who proposed to substitute wood.

Mons. de la Rive read a paper in French on *Electro-Magnetic Currents*, and one on an optical phenomenon at Mont Blanc, which elicited from Messrs, Lloyd, Lubbock, and Stevelly, descriptions of similar phenomena which had been observed by them in this country.

Major Sabine laid before the Section a table of the results of observations of several persons on *Terrestrial Magnetism.* Mr. M'Gauley then brought forward a paper on *Electro-Magnetic Apparatus*, and the importance of endeavouring to apply magnetism as a moving power to machinery, and exhibited an apparatus, from which a rapid succession of sparks of considerable power was obtained.

Mr. Holden read a paper on the *Atmosphere of the Moon*, the existence of which had long been doubted by astronomical writers, principally because there was no water on the moon's surface. Mr. Holden's opinion was in favour of the existence of an atmosphere, for four reasons:—first, that the irregularities on the moon's disc indicated the existence of a medium capable of reflecting rays of light; secondly, that it was proved by the projection of the horns of the moon, while crescent beyond its semi-diameter, that rays of light are refracted on the circumference; thirdly, that the existence of a medium of combustion was proved by the appearance of fire observed by astronomers; fourthly, the appearance of stars on the front of the moon at a considerable distance from the disc.

After some observations on this subject, and the reading of a Report by Lieutenant Morrison on the *Electricity of the Atmosphere*, with a view of measuring by an instrument its extent and intensity, the Section adjourned.

On Thursday, after the reading, by Mr. Lubbock, of a Report by the Committee for preparing *Empirical Tables of the Moon*,

Professor Henry read a paper on the *Lateral Discharge in Common Electricity*, which had hitherto been little, if at all considered. In discharging a leyden jar by a perfect conductor, a lateral discharge also took place from the jar itself. Professor Henry gave a variety of details on this subject, and mentioned, among other facts, that if the shock be conveyed along two wires, placed along each other with their sides in contact, there would be a lateral discharge from the exterior edges, but at the interior edges the opposing currents of the lateral discharges would neutralize each other.

A paper of Sir David Brewster's on the *Crystalline Lens* was read by the Secretary, which was followed by a paper from

Dr. Reade on the production of a permanent *Soap Bubble for showing Newton's Rings*, which had long been a desideratum. He proposed to take two ounces of a solution of Castilian soap in distilled water, and, inclosing it in a phial, to insert it in boiling water, until he produced a vapour which filled the bottle; the mouth of the bottle must then be closed, and a perfect vacuum would be left in the upper part by the condensation of the vapour. Bubbles might then be obtained, which should remain long enough to allow of their being examined.

A paper was read by Professor Christie on the *Aurora Borealis* during the last summer, in every month of which it had been observable. On one occasion dark arches had appeared to break in upon the luminous arches, and it was important to determine the connexion of these phenomena with magnetism, especially as a disturbance of the magnetic influence, contemporaneous with the aurora, had been observed at the *same time* time in England and America. After an interesting conver*sation*, Mr. Snow Harris read a Report of *Meteorological Observations* made by him at Plymouth during the last five years; and Dr. Lloyd announced the probability of similar observations being taken in Ireland by the officers engaged in the survey of that country.

A Report was read by Mr. Southwell, of observations made by him on *Mr. Whewell's Anemometer* (see first day's proceedings), and some improvements in it were suggested, in the propriety of which Mr. Whewell concurred.

After the reading of a paper by Sir D. Brewster on a new property of light,and a Report by Professor Lloyd on *Simultaneous Observations on the Horizontal Needle*, Captain Denham exhibited an improved mode of producing a *Red Light in Light-houses*, the advantage of which, however, Sir D. Brewster, Dr. Faraday, and others, doubted.

On Friday the business commenced by Mr. Lubbock's bringing before the notice of the Section the opinions of M. Poisson on the *Constitution of the Atmosphere*. It being premised that air was an elastic fluid, the question was, to what extent did its elasticity continue, when it became more cold as we ascended? M. Poisson believed that it was impossible it could be terminated by a surface of its own nature, and considered it as divided into three layers, the pressure of the exterior of which kept the centre one in its place. The air above, he thought, lost its elasticity. In this case Mr. Lubbock said it might become a solid; and if we admitted that the air was bounded by a surface differing from itself, we should arrive at the idea of a surface of ice with its reflecting properties, but as no such reflections were observable, this hypothesis could not be tenable. Sir D. Brewster saw several objections to the theory from the laws both of reflection and refraction; and Professor Stevelly considered it untenable, both from the supposition of the particles of the atmosphere being unlimitedly small, and from the extremely low temperature, or rather unlimited cold which it required.

Professor Phillips read a paper on *Subterranean Temperature*, a subject on which a grant of 100*l*. had been expended. Seventy-two thermometers had been given out with tables of registry, which were not yet filled up. The variation of the sun's influence was not beyond a certain depth. At Wigan, in a colliery, the surface temperature was about 50°, 50 yards deep, the temperature was constant 53°, at 150 yards, constant 56¾°, at 250 yards 63°, it being remarkable that the change in this instance was about 1° for 16 yards, while in France it was 1° for 15 yards. The neighbourhood of water affected the results, and different conducting powers were found in different rocks, so that twelve months might elapse before the sun's heat would penetrate a depth of twenty-six feet.

Major Sabine read a *Report of Magnetical Observations*, and in a conversation which ensued relative to the dip, it was stated that the difference between various needles was as much as from thirty to forty minutes.

Dr. Robinson gave the results of his own observations on the *Parallax of Alpha Lyræ*, varying from a mean of 1·28″, in 78 observations, to 0′·20″ in 70 others, whereas Dr. Brinkley had, twenty years since, given a parallax to that star of 1″.

A paper by **Professor Powell** on the *Radiation of Heat*, one by **Mr. Mackie** on the *Tides of Glasgow and Dundee*, a new application by **Sir W. Hamilton** on the *Calculus of Principal Relations*, some observations by **Mr. Ettrick** on the *Velocity of Electricity*, and a description, by **Professor Christie** of some phenomena seen at sunset in the Isle of Wight, closed the business of the Section.

Section B.—CHEMISTRY AND MINERALOGY.

President.—Dr. Faraday.

Vice-Presidents.—Professor Daniell, Professor Graham, Dr. Apjohn.

Secretaries.—Professor Johnston, Dr. Reynolds, Professor Miller.

Committee.—Mons. De la Rive, Dr. Thomas Thomson, M. Gay Lussac, M. Liebig, Dr. Yellowly, Professor Cumming, Mr. Richard Phillips, Mr. W. Herapath, Professor Edmund Davy, Dr. Andrews, Professor Clark, Mr. W. Lucas, Mr. H. H. Watson, Dr. Kane, Mr. Mackintosh, Dr. R. D. Thomson, Mr. Thomas Thomson, jun., Mr. Charles Tenant, Mr. Crossall, Mr. Robert Mallet, Mr. Walter Crum, Dr. Inglis.

CHEMISTRY.

Dr. Kane explained the nature of *Pyroacetic Spirit*. If acetate of barytes be exposed to a certain temperature, carbonate of barytes will remain in the vessel, a fluid somewhat similar to alcohol being separated. This is pyroacetic spirit; and in order to understand the alteration it undergoes, it is to be considered in its formation, and as being C. 6 H. 6·62. It is very similar to alcohol, of which there are two compounds known, common wine alcohol, and common pyroacetic spirit.

Mr. G. J. **Griffin** brought forward specimens of various *Chemical Apparatus* which he had constructed, and which were highly praised by the practical chemists present, especially the improved test-holder, constructed so that the tube might be turned vertically or horizontally without metal sockets or screws, which were liable to be injuriously affected by the fumes of a laboratory. A good set of Mr. Griffin's might be obtained for from 5*l* to 10*l*.

Mr. J. B. Hartley read a paper on preventing the *Corrosion of Cast and Wrought Iron in Salt Water*, in which it was shown that in several instances where iron had been immersed for a very long space of time—such as twenty-five years—it had been preserved by being placed in connexion with brass, while it corroded in a much shorter space of time, if not so connected.

Dr. Andrews gave an account of some curious modifications of the *ordinary Action of Nitric Acid on certain Metals*, mentioning among other things that, by putting a piece of platina in connexion with a metal while violently acted on by nitric acid, the action of the acid ceased almost completely, the metal however generally changing its colour. He imagined that a current of nitrous acid gas was produced by the platina round the metal, which was thus preserved from the action of the acid. Dr. Faraday remarked, that it might have been the same influence which protected the cast-iron from the action of the sea-water, and that nothing could be more important than such investigations.

Dr. Apjohn communicated some observations relating to a *new* *compound of Iodide of Potassium, Iodine and Cinnamine*, accidentally observed at Dublin, in a solution containing iodide of potassium and cinnamon-water. The mixture was at first clouded, but in a few days became perfectly clear, leaving a crystalline sediment at the bottom, of a fine bronze colour, which was soluble in ether and alcohol, and was decomposed by hot water, the iodine being precipitated. It was so volatile, that it would not fuse unless at an atmospheric temperature of 32°. It melted at from 68° to 70°. By urging the heat, the substance is decomposed, and the iodine evaporating, leaves behind it a deposit of iodide of potassium. The composition of the substance was, he believed, 1 atom of iodide of potassium to 3·95 or nearly 4 of iodine, the number of atoms of cinnamine being 5·6. Dr. Apjohn gave a description of the best mode of producing the compound, and concluded by saying there was no doubt that cinnamine could be extracted in this way, and that it was the first combination of a negative element with a metallic base. Dr. Kane doubted the possibility of such a combination.

PROFESSOR GRAHAM read a paper on the *Construction of Salts*, particularly those containing ammonia, and asserted that water formed the base of most of them, ammonia being merely a basic adjunct. Salts he designated oxalates of water. Considerable difference of opinion was expressed on this subject.

DR. CLARKE made a communication on the simplification of the *Calculations relative to Gases.*

A letter from PROFESSOR HARE of Philadelphia, stated that he had succeeded in *melting platinum* in masses, by an oxy-hydrogen blow-pipe.

DR. TRAILL read a paper on a *New Compound of Antimony as a Pigment*, lately discovered by him, having produced a beautiful blue prussiate by adding a solution of ferro-prussiate of potash to muriate of antimony. Drs. Faraday and Apjohn thought it merely a mixture of Prussian blue with oxide of antimony.

DR. N. ARNOTT proposed a *New Safety-Lamp for Mines*, on the principle of supplying lamps at fixed stations with air from the surface by pitched wooden pipes, to which hose might be attached, where it was necessary to move the light.

MR. PEARSALL read some observations on the action of rain-water upon lead, and believed that, where persons had been poisoned by lead in water, the water contained lead in solution as well as in precipitation.

PROFESSOR LIEBIG read a paper on the *Products of the Decomposition of Organic Bodies*, with the results of experiments, and recommended that greater attention should be given by English chemists to organic chemistry,—an opinion in which Dr. Thomson and Professor Kane agreed. The former of these gentlemen brought forward some observations on the specific heat of water and alcohol.

MINERALOGY.

THE *Manufacture of Iron* occupied a very large portion of the time of the section. The first paper on this subject was by Mr. G. CRANE, of Ynyscedwyn Iron Works, on the smelting of iron by anthracite coal, of which fully a third of the immense coal field of South Wales is composed. Mr. Crane had smelted a ton of iron with 27 cwt. of anthracite coal with very satisfactory results as to quality, and found a very considerable saving in using it in preference to bituminous coal. The smelting was now conducted by a cupola furnace, into which a stream of air was urged of a heat sufficient to melt lead, this hot blast being all that was requisite to produce the combustion of the coal necessary for the reduction of the ore.

Dr. Thomson gave an account of the results of the experiments carried on at the request of the Association, on the *Comparative Advantages of Hot and Cold Blast Iron.* He had analyzed more than thirty specimens of the Glasgow ore selected with great care, the richest of which had a specific gravity of 3·056, with nearly 85½ per cent. of iron. The roasting of the ore before it was put into the furnace, in order to drive off the carbonic acid, reduced it 35 per cent. Formerly in smelting, ten tons of coal were used for the reduction of one ton of iron. In 1823, when the hot blast was introduced, 2 tons 19 cwt. only were required; 19 cwt. being consumed in heating the air and the boiler of the steam-engine. Coals were therefore greatly economised by the hot blast, which produced a concentration of the combustion, and therefore melted the iron in a greater degree. A smaller quantity of lime was required for fusing the clay, and hence a greater quantity of cast-iron could be obtained from a furnace in a given time. He had been, from the Carron Iron Works, which were of high reputation, supplied with specimens of No. 1 iron, made from hot and cold furnaces, and found the gravity of the cold blast less than that of the hot blast iron. One specimen of the cold blast iron, No. 2, contained 90½ per cent. of iron. From five specimens of the hot blast from different places, he had obtained a mean of 95½ per cent of iron. Hot blast was decidedly purer than cold blast full 5 per centt., and they were of equal strength*. The force required to break both sorts was the same, being 2040 lbs., where the iron was ⅜ths of an inch thick. A chain of ⅞ths thick, forged from hot blast iron, had stood the test of 22 tons 7 cwt., twelve tons above the Liverpool chain cable test. The saving in the coal by hot blast was two-thirds. No phosphorus had been found in the iron analyzed by him.

Mr. Guest had found a much larger portion of the hot blast lost than of the cold blast in converting it into malleable iron.

Professor Johnstone read a report on *Dimorphous Bodies*, the result of which was, that there must be a molecular difference between the crystals of these bodies.

Dr. Apjohn introduced a new description of *alum*, found in alluvial passages in strata of great thickness, averaging in some places 30 feet, the crystals of which were fibral.

Two other papers were read, one by Professor Johnstone, on the *Description and Properties of a Description of Hatcheline*, the other by Professor Miller, on the expansion of *Crystals* in different directions.

Considerable interest was excited by Mr. Golding Bird's paper on the *Crystallization of Metals by Voltaic Agency*. His apparatus consisted of an external cylinder of glass, eight inches in height and six wide, and an interior conical cylinder of glass six inches in height and two in width. The bottom of this second cylinder was filled to the height of an inch with plaster of Paris. The external cylinder is filled with a weak solution of common salt, while the internal smaller cylinder is filled with a solution of the salts. The copper, or negative electrode, is immersed in the interior cylinder, and connected by means of a copper wire with the zinc or positive electrode in the exterior cylinder. After the battery had been some time in action, Mr. Bird found minute metallic crystals collected in the plaster of Paris, and thus he imagined that metals were formed by electric agency in the bowels of the earth. Dr. Faraday said, the important circumstance was the origination of the atom out of contact with the extremities of the electrodes.

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* *On this subject* see Mr. Fairbairn's paper in the section of Mechanical Science.

Mr. Black read a paper on the *Injurious Action of Electricity on Brewing*, which he proposed to prevent by insulating the fermentation tub.

Professor Davy introduced a new *Gaseous Carbo-hydrogen*, prepared by repeatedly passing the electric spark through bicarburetted hydrogen.

Section C.—GEOLOGY AND GEOGRAPHY.

President—Rev. Professor Sedgwick—(*For Geography*) Mr. G. B. Greenough.
Vice Presidents—Mr. Leonard Horner, Lord Cole, M.P., H. T. De la Beche, F.R.S.
Secretaries—Captain Pollock, R. Hutton, Esq., M.P.
(*For Geography*) Captain H. M. Denham, R.N.

Committee—Mr. James Bryce, Sir Philip Grey Egerton, Mr. W. J. Henwood, Mr. James M'Adam, Major Sabine, Mr. H. E. Strickland, W. West, M.D., Mr. H. T. M. Witham, Rev. M. Dwyer, of Liverpool, Mr. W. B. Clarke, Mr. Richard Griffith, Mr. B. Ibbotson, Col. Silvertop, Mr. R. I. Murchison, T. S. Traill, M.D., Rev. James Yates, Professor Phillips, Major Shadwell, Chester.

Mr. Mallet introduced a paper on a new theory of the *Motion of Glaciers*, which the author said could not be attributed, according to the common theory, to their descent down an inclined plane by the force of their own gravity, but to hydraulic pressure, from the melting of the glacier nearest the earth, forming, as it were, liquid rollers, which pressed the glacier onwards when it was lifted up by the heat.

In relation to the surface of the earth itself, the Rev. W. Whewell made a report *On the Relative Heights of the Land and Sea*,—a subject which had been entrusted to a committee for investigation when the Association met in Dublin, and a sum of 500*l.* granted by the general committee to meet the expenses of the inquiry. The report was necessarily incomplete, the inquiry being still in progress.

Mr. W. E. Strickland drew attention to the superficial strata in a very important paper on the *Gravel Formations of England*, with which, of course, must be connected the upheaving process by which mountains are supposed to have been formed. The English gravels are of two species, marine and fluviatile; the former was certainly deposited when the land of Britain lay below the surface of the ocean; but since that unknown geological period, immense beds of lacustrine and fluviatile deposits have been formed by the action of lakes and rivers no longer in existence. From a series of observations on these beds, it seems exceedingly probable that there was once an open water communication between the Mersey and the Avon, and consequently that Wales must be one of the most recent formations in Britain. Some amusement was excited by this attack on the antiquity of the principality, which served to enliven the very elaborate discussion to which the reading of the paper gave rise.

The subject of *Fluviatile Deposits* was brought under the notice of the section by CAPTAIN DENHAM. It was one of great practical importance to all who live near the sea, but its local value, in relation to the port of Liverpool, was inestimable; in fact, the continued encroachments on the estuary of the Mersey have led to the accumulation of sand-banks, threatening utter ruin to the harbour. Many persons suppose that the deposits of silt or mud are owing either to the flow of the river or the tide of flood. Captain Denham distinctly proved by experiment that they were owing to the tide of ebb, from whence it plainly followed that all encroachments on the river, however useful to man, were dangerous, if not destructive, to the harbour.

At a later period, the subject of fluviatile deposits was revived by Mr. SMITH, who read some strictures on Mr. Strickland's statements, but he left the general results which had been obtained quite unshaken.

MR. HOWE read a paper on the *Tidal Motions of the Severn*, confirming Captain Denham's account of the Mersey.

MR. YATES read a paper on the *Fossil Vegetables* found in the red sandstone of Worcestershire. It is only within the last few years that organic remains and impressions of vegetables have been discovered in this formation. Great trunks of trees, similar to those found in Saxony, have been discovered near Coventry; and one magnificent specimen, found in excavating the Prince's Dock, was preserved in the Royal Institution of Liverpool*. Mr. Yates then insisted on the probability of red sandstone having been originally either a fluviatile or a marine deposit. The discussions on the red sandstone were more purely scientific than any others in the section; but the most important practical matter elicited was from Professor Sedgwick, exposing the error of those who believe that there is invariably a coal formation under the new red sandstone, an error which had led to considerable expense by sinking shafts which led to no profitable result. The cause of such a failure is one of the many valuable discoveries for which geological science is indebted to Professor Sedgwick, for it was he who discovered a new formation between the sandstone and the coal; it is a species of magnesian limestone, of which we believe that the stone pier of Whitehaven is built.

Coal formations occupied a considerable share of attention. Dr. CROOK read a paper on the *Unity of the Coal Formations* in England and Wales. Mr. Younge directed attention to the coal mines of Nova Scotia; Messrs. Heywood and Williamson gave elaborate accounts of the coal formations in Lancashire; those in Wigan and other districts were described at great length by different members. One incident of the discussion must be recorded. Professor Sedgwick gave an account of an irruption of the sea into the collieries at Workington; and described in such an animated manner the heroism of an Irish miner, who had periled his life to save an old man and two boys, that the entire section rose in a fit of enthusiasm, declaring that a subscription should be raised to reward such a rare union of humanity and bravery. About forty pounds were collected in the space of a few minutes, which Professor Sedgwick undertook to transmit to "*his Irish friend*," in whose name he returned thanks to the section.

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* We went to see this fossil wonder; it is a trunk of some species of the fir or larch tribe, about fourteen feet in length and two feet in circumference; until *actually handled*, no one would believe that it was a fossil, so perfect is the preservation of the bark, and of the minutest fibre in the section; when struck, it gives out a sharp ringing sound, not unlike that of porphyry.

The subject of *Metalliferous Veins* was brought forward by Mr. Henwood, of Cornwall. He stated, as the result of a long series of observations, that the formation of these veins was cotemporaneous with that of the strata in which they were embedded. This being about the most disputable point in the whole range of geology, gave rise to a debate, long more remarkable for clashing theories than a definite statement of fact. One practical result of a remarkable nature followed. It appears that the rules for discovering a lost vein, which have been invariable in their success at Wigan, have generally, or at least frequently, been found to fail. This was an unexpected view of the case, and in the absence of positive knowledge, it was discussed very much at random.

Of the miscellaneous subjects brought before the section, we must mention *Geological Maps;* one of France was exhibited by Mr. Greenough, and it was announced that one of Ireland was on the point of publication.

Sir Philip Egerton brought forward a paper furnished by Sir David Brewster, establishing indisputably the *Vegetable Origin of the Diamond.* It is now as certain that crystallized carbon is of vegetable origin, as coal itself. Layers of different degrees of hardness, and possessing different powers of refraction, have been found in the diamond; and these layers, which are superimposed on each other like the coats of an onion, possess different specific gravities. It was inferred that the diamond, in its pristine state, must have been a soft body, like amber or gum, and that it was probably expanded by the gaseous bodies imprisoned in its cavities. In commenting on this paper, Professor Sedgwick announced a fact new to us, and probably so to most of our readers, namely, that particles of silica had been discovered in the ashes of burned wood.

Mr. Hodgkinson's paper on the *Refrigeration or gradual cooling down of the Earth*, supposing it once to have been a mass of molten fluid, led to a very general discussion of geological theories, and to the more hazardous subject of their consistency with the Mosaic accounts of the creation. The debate was long and interesting.

This section continued its meetings to Saturday, when several papers were read; but as the authors were dissatisfied with the very limited attention they received, and have resolved to bring the subjects before the public in another shape, we do not include them in this brief report.

SECTION D.—ZOOLOGY AND BOTANY.

President.—W. Sharpe Macleay, F.L.S.

Vice Presidents.—Dr. Richardson, Professor Graham, Professor Lindley.

Secretaries.—C. C. Babington, F.L.S., W. Swainson, F.L.S., Rev. L. Jenyns, F.L.S.

Committee.—Rev. Thomas D. Hincks, LL.D., N. A. Vigors, F.L.S., Rev. F. W. Hope, F.L.S., Pat. Neill, LL.D., Professor J. S. Henslow, T. S. Traill, M.D., Earl of Derby, Rev. W. Hincks, F.L.S., John Curtis, F.L.S., P. B. Duncan, F.L.S., J. E. Gray, F.R.S., Mr. C. S. Parker, Rev. J. Yates, Messrs. J. E. Bowman, T. Eyton, J. P. Selby, C. Horsfall, R. Ball, L. W. Dillwyn, J. N. Walker, A. H. Haliday, J. T. Mackay, Capt. Jas. Ross, Sir W. Jardine, Messrs. R. Harrison, Tinne, H. Sandbach, J. Salisbury, — Green, Dr. Duncan, Messrs. F. Archer, G. Cook.

OF the subjects discussed in this section, there is one which has made too much noise in the world to be omitted, namely, the experiments of Mr. Crosse, who had produced living animalculæ in a solution of silica, subjected to the agency of voltaic electricity. Mr. Crosse himself made no attempt to account for these beings, but there were many who did not display the same caution. Some believed that, like another Frankenstein, he had discovered the mystic principle of life; others, more moderate, averred that he had revived these creatures from the torpidity in which they remained during the myriads of years which must have elapsed since silex was in a fluid state. Upon the experiments being repeated with the greatest accuracy by three distinguished naturalists and chemists, no animalculæ were produced; and upon Mr. Crosse's specimens being examined by entomologists, they are ascertained to be the common little mite, so destructive to books and furniture, whose ova had probably been introduced into the distilled water, and prematurely developed by the galvanic action.

A new species of water-lily, called *Victoria Regalis*, recently discovered at Berbice, was described, and drawings of it exhibited. It is quite a giant of the vegetable world, and is indeed a most wonderful and beautiful specimen of vegetable nature.

SECTION E.—MEDICAL SCIENCE.

President.—William Clark, M.D.

Vice-Presidents.—James Carson, M.D. F.R.S., Peter Mark Roget, M.D. Sec. R.S., Robert Bickersteth, Esq., Professor R. T. Evanson, M.D. M.R.I.A.

Secretaries.—James Carson, jun. M.D., J. R. W. Voss, M.D.

Committee.—Neil Arnott, M.D. F.R.S., Richard Bright, M.D. F.R.S., Hugh Carlisle, M.D., James Copland, M.D. F.R.S., Professor Richard T. Evanson, M.D. M.R.I.A., Richard Formby, M.D., Augustus B. Granville, M.D. F.R.S., John Houston, M.D. M.R.I.A., James Johnson, M.D., James Macartney, M.D. F.R.S., Charles Herbert Orpen, M. D., William Henry Porter, Esq., Charles B. Williams, M. D. F. R. S., John Yellowly, M. D. F. R. S.

THE only subject brought before this section, which comes within the scope of our work, is the report of the committee on the *Sounds of the Heart.*

Our readers are, of course, aware that an instrument, called the *Stethoscope*, was invented some years ago, by which a physician is enabled to hear certain sounds and motions within the human frame, indicating the operations of the vital functions, and helping us to discover whether the necessary processes of life are going on in a healthy or an unhealthy state. Those sounds which indicate the natural or healthy progress of the functions, are called *Normal;* those which show that vital operations are interrupted or suspended by disease, are called *Abnormal*. To distinguish them, however, requires extraordinary nicety of observation, great experience, and a naturally delicate perception in the organ of hearing. A great similarity, if not a perfect identity, has been observed between the normal sounds, and those caused by the uninterrupted flow of a fluid through an elastic tube; but if mechanical impediments to the course of the stream be inserted in the tube, then the sounds will be similar to the abnormal sounds heard in examining a diseased state of the human frame. Now there is a very perceptible difference in the sounds of the deranged tube, according as the mechanical impediments are interposed near the summit or near the bottom; but the difference is not very great, when we merely change the position of the orifice or the vent. Hence it seems probable, that an attentive consideration of these sounds may enable physicians, in a great number of instances, to determine the seat of disease, or, in other words, the exact spot where an impediment is interposed to the performance of the vital functions, an advantage on whose importance it is unnecessary to dilate. "The discoveries of the committee prove," says Dr. Roget, "that grave philosophers, so long regarded as insensible, passionless, and cold, have at length begun to understand, appreciate, and interpret the language of the heart."

SECTION F.—STATISTICS.

President.—Lord Sandon, M. P.

Vice-Presidents.—Colonel Sykes, Mr. G. R. Porter, Mr. J. Heywood.

Secretaries.—Mr. W. R. Greg, Dr. W. C. Taylor, Mr. W. Langton.

Committee.—Dr. Jerrard, Mr. Hovendon, Mr. Fripp, Dr. Carpenter, Mr. H. Romilly, Colonel Briggs, Mr. Corrie, Mr. W. Wyse, M. P., Mr. Slaney, M.P., Mr. Urquhart, Dr. Kay, Mr. Tuffnell, Mr. Chadwick, Mr. S. J. Loyd, Mr. Simpson, Lord Nugent.

MR. PORTER read an interesting paper on the trade between Great Britain and the United States, to which recent events have given a deep, we might almost say, a painful interest.

COLONEL SYKES read an abstract of a very large work on the statistics of the Deccan, very varied and miscellaneous in its character. The practical points most useful to Englishmen were, that some of the Indian grains are far more productive than any known in Europe, and might perhaps be advantageously cultivated in this country; that many vegetable productions of the district could be rendered available in British manufactures; and that the progress, both of native and British trade, is seriously impeded by the onerous nature of the transit duties.

Colonel Sykes also gave an account of the labours of the agricultural and commercial committee recently established by the Royal Asiatic Society. Though this committee has been very recently established, it has introduced several new dye-stuffs, some varieties of lichens, and a substitute for hemp, to the notice of British manufacturers.

In educational statistics, there were papers read on the *State of Education* in York by Mr. Greg, in Bolton by Mr. Ashworth, and in Liverpool by Messrs. Merritt and Tate. The general result of all, shows that a very large proportion, amounting nearly to one-half, of the children between five and fifteen attend no school, that a large division of the others attend Sunday-schools only, and that the quality of the education given at dame-schools and common day-schools is so bad, that it would be as well, if not better, for the children, to be left wholly without the instruction given by unqualified teachers. It was strenuously and very plausibly urged by Messrs. Merritt and Tate, that too unfavourable a view was given of English education, by taking the decennial period between five and fifteen; for many sent their children to school before that age, and most of the operatives engaged their children in active occupations at the ages of twelve or thirteen; they therefore proposed the septennial period between five and twelve, as a more accurate standard for determining how far the opportunities afforded for the acquisition of knowledge were adequate to the wants of the rising generation. But from a very different series of investigations, undertaken by the Manchester Statistical Society into the actual condition of the working population, the more unfavourable view of the state of education in this country was not only confirmed, but considerably aggravated. The York report was particularly valuable for the minuteness of its details, and for the care taken to render the tables as accurate as possible.

To educational statistics, we must also refer an abstract of the annual report made by the regents of the University of the State of New York to the local legislature, on the state of education in the schools subject to their control. The design of Dr. Taylor's abstract was to show the precise extent of interference of the local governments in the United States in the management and discipline of schools; and also to point out the great range of practically useful subjects opened to youth in the state of New York.

There were two general inquiries into the state and condition of the working classes, one from the Manchester, and one from the Bristol Statistical Society; they embraced a wide range of topics, all of which, however, directly bore on the morals, comforts, health, and social enjoyments of the operatives and the labourers. The first point was the nature of their dwellings. In the majority of instances these were found to be ill-ventilated, dirty, without a proper supply of water and other conveniences necessary to cleanliness; and a frightful number of examples appeared, in which all feelings of delicacy, the great safeguard of purity both in mind and conduct, must necessarily have been destroyed, from grown persons of different sexes occupying the same apartment. The details given of the life led in courts, cellars, garrets, and other purlieus of misery, were perfectly astounding, and excited feelings of horror in all who had never inquired into the subject.

The agricultural papers were those of Mr. WEBB HALL, on the *Progress of Agriculture* during the last century, especially as relates to the cultivation of the potato and the turnip; Dr. YELLOLY on *Spade Husbandry and Cottage Allotments;* and Mr. BERMINGHAM on the *Drainage of the Bogs in Ireland.*

The only paper on *Medical Statistics*, was Mr. URQUHART's, on the localities of the *Plague in Constantinople.* He attributed, if not the cause, at least the aggravation of this disease, to the vicinity of cemeteries raised above the level of towns and villages. Pestilential vapours rose from the putrescent bodies, the more fatal, as the Turks, from *religious motives*, never bury their dead in deep graves.

SECTION G.—MECHANICAL SCIENCE.

President.—Rev. T. Robinson, D.D., F.R.S.
Vice-Presidents.—Dionysius Lardner, LL.D. F.R.S., Professor Wheatstone, London, Professor Willis, Cambridge.
Secretaries.—William Ritchie, LL.D. F.R.S., Thomas Webster, Sec. I.C.E., Charles Vignolles, C.E.

Committee.—John Scott Russell, F.R.S.E., John Taylor, F.R.S., John Robinson, F.R.S.E., Davies Gilbert, F.R.S., Dr. Traill, F.R.S.E., George Rennie, F.R.S., Rev. John Blackburne, Pres. Sheffield Phil. Soc.—*Associates:* Messrs. John Isaac Hawkins, C.E., William Fairburn, Peter Clare, George Forrester, Edmund Bury, William Fawcett, Henry Booth, Hardman Earle, Joseph Locke, David Hodgson.

THE proceedings of this section may be divided into the following heads: —Modifications and effects of the Moving Power in Canals, Railroads, Steam-engines, &c.; Strength and Durability of Material; Mechanical Instruments; and Miscellaneous Application of Mechanical Science.

Among the most interesting of the subjects brought before the Association at their last meeting, were the *Motion of Steam Vessels in shallow Water*, the phenomena attending it, and the effect of peculiarities in the construction of channels and embankments, on all of which, Mr. RUSSELL, of Edinburgh, afforded much valuable information. The first paper brought forward by him in this section, was on the Mechanism of Waves, in relation to Steam Vessels in shallow Water, in which he gave the practical application of the series of experiments which he had made on this subject. It was found, that in rivers, steam-navigation was exposed to much greater disadvantages than in the open sea. These disadvantages arose from three causes; 1st, From the great wave of anterior translation; 2dly, From the formation of lateral currents, and 3dly, From the stern wave, or posterior surge. The first of these, the great anterior wave of translation of the displaced fluid, reached to the full depth with equal velocity, and was generated by the heaping of the water on the side of the vessel, produced by the increase in the velocity of propulsion. Its velocity was equal to the fall of a stone through half the depth, and it sometimes extended for a mile and a half, increasing very considerably the depth of the water, and the resistance to the progress of the vessel, which was doubly impeded by the anterior wave and the stern depression. This wave was to be diminished, not by widening, but by deepening the channel, and by making the difference between the velocity of the vessel and that of the wave as great as possible. The formation of lateral currents, having the same direction with the motion of the paddles, and therefore greatly diminishing their power, was the next evil. This and that arising from the posterior surge, were to be remedied by deepening the channel, and making its sides as vertical as possible, the rectangular form of channel being in every respect preferable. There was another wave, which Mr. R. termed that of unequal displacement, which diverged from the bow towards the stern of the vessel on both sides; and this was to be remedied by sharpening out the vessel towards the bow, so that her lines of displacement should be slightly concave. Mr. Russell's form for a vessel, at least so far as regarded the remedy for the evils he mentioned, would be one with a long sweeping concavity towards the bow, having the maximum breadth amidships, and a convex sweep thence to the stern.

The second paper given by Mr. Russell, was on *Tides, and Tidal Waves in Rivers*, it being of great importance to determine the means by which the tide might be brought up most rapidly and furthest, and retained longest. The velocity of the tidal wave was similar to that of the anterior wave before spoken of, and it was therefore increased in the same way by deepening the channel. The shape of the banks had, with respect to it as to the other, a material influence, the velocity being increased fully one-third, by adopting vertical, in preference to sloping banks; next, with regard to the bends of rivers—the tidal wave might be made to move in any given curve by deepening the channel at the exterior side in a given ratio with the interior. The effect of these curves would be double: first, to admit the tide as rapidly as possible, and secondly, to retain it to the longest possible period. The tide might also be brought higher in a river, by gradually narrowing the channel from a wide mouth. It was of importance too, to prevent the formation of tidal bores, or large waves, which sometimes rose to a great height, so as to swamp all the smaller shipping. These bores were found where the water was not of great depth, and as they could not exist, unless the depth of the water was less than their own height, the simple and effectual remedy for them was found in deepening the bed of the channel.

Mr. Russell's third paper, on *Sea Walls and Embankments*, was intended as a sequel to the two preceding. The object of such walls was to resist the secondary wave of the sea, which might be made to break at any given point, by placing a solid body below it so as to make the depth of the water only equal to its height. Several forms of embankments had been tried, the vertical, the inclined plane, and the concave; but he recommended the convex curve of a parabolic form, the slopes increasing as the squares of the distances, so that the wave being gradually broken on it, might have its velocity reduced to nothing, when it reached the summit. The vertical wall had a double duty to perform, having to *reflect* the waves, as well as stop their progress, and the effect of this reflection was to make the water near the embankment alternately smooth and rough, so as greatly to endanger small vessels.

To the first division of the subjects submitted to the Section, may be referred Dr. Lardner's observations on the *Applicability of Steam to Long Voyages*, especially to that across the Atlantic. Dr. L. having so frequently detailed his opinions on these subjects, and the calculations on which they are founded, we may be excused for omitting them at present, especially as his objections in some degree to the practicability, but still more to the utility of long voyages by steam, were completely overturned by actual evidence brought forward by Mr. Guppy and others. It was mentioned by these gentlemen on the authority of the *Nautical Magazine*, that the Atalanta and Berenice had performed very long voyages, at a speed much greater than that which Dr. L. supposed practicable, and one of them, after a run exceeding 2000 miles, had sufficient coals still on board to have carried her over more than an equal distance. It was also proved, by the testimony of several gentlemen, that the voyage up the Hudson was performed at the rate of fifteen or sixteen miles an hour, including stoppages, being five or six miles more than the speed computed by Dr. L.

Dr. Lardner, in the course of his observations, objected to *Hall's Condenser*, on account of the size of the air-pump, which, if required to effect a vacuum, must produce it by pumping out uncondensed steam. which was a mere waste. Several gentlemen bore testimony to the utility of the condenser in question, and Mr. Hall has since published an answer to Dr. L.'s objections. He had also objected to *Morgan's paddle-wheels*, as expensive and not durable. This Mr. Cottam answered, by instancing several cases, where after being exposed to very severe trials, these paddle-wheels had borne them without the slightest injury.

Two steam-vessels are now in progress of building, one in Bristol, and another in London, on the grandest scale, the arrangements of which promise fair to overcome all the difficulties of our longest sea voyages. One of these will have two engines, of 200 horse power each, cylinders of 73½-inch diameter, and cycloidal paddles, her burthen being 1,300 tons. The other will be of 1,800 tons burthen, and will have 78-inch cylinders. An American engineer, Mr. Allan, has undertaken to forward to the Association before their next meeting full particulars as to the performances, &c. of the American steamers.

Dr. Lardner brought forward, in addition to what we have already mentioned, a paper on the *Resistance to the Moving Power in Railways*, and pointed out the difficulty of arriving at the truth either by the dynamometer, or by measuring velocities on inclined planes. He corrected some algebraical formulæ by introducing into the calculations the gyration of the wheels, and then proceeded to calculate the friction by the following plan:—He took a train loaded up to the full point, and allowing it to travel very slowly, calculated the pressure on the piston minus the momentum overcome and the presumed friction of the engine, and then took the difference of the tractile force, assuming *an uniform pressure* of fifty pounds per inch on the cylinder. He did not believe the resistance of the atmosphere need be taken into account. From this latter opinion all the gentlemen present widely differed, particularly Mr. Vignolles, Mr. Roberts, and the President. The latter mentioned that in the pendulums of astronomical clocks a difference of ten seconds a day was produced by the sticking of the air; and Mr. Roberts mentioned a case when he had actually been blown along the rail-road by a huricane, at the rate of eighty miles an hour, without steam. Mr. Herapath added, in confirmation of the necessity of allowing for atmospheric resistance, that having found that his calculations as to speed were widely different from the results given in practice, he had found that by allowing for the resistance of the air, theory and practice exactly agreed. Mr. Hardman Earle mentioned that during Dr. Lardner's experiments, at which he was present, the steam was certainly blowing off, and that Dr. L. had been mistaken when he gave a contrary opinion.

To the modifications and effects of the moving power is also to be referred Mr. Henwood's paper on the duty of *Cornish engines*, in which that gentleman, from a series of experiments of considerable duration, deduced a much lower amount of duty than had in some instances been said to have been obtained. Mr. H. had never obtained more than ninety or ninety-one millions, and believed that where 125 millions had been reported, the experiment could not be considered a fair one. At all events, he attributed little if any value to experiments of so short duration as those by which these very high duties had been obtained. Mr. John Taylor and Mr. Lane, being questioned on this subject, stated that 125 millions had been fairly obtained, but that it had been from an experiment of about twenty-six hours, which they agreed with Mr. H. in considering much too short to afford a fair test of the effective duty of the engine. Mr. Taylor suggested some additional tests of the duty, but all concurred in thinking that the amount of water discharged was the only really correct method of ascertaining it.

Under the division of *Strength of Material*, are included two papers by Mr. FAIRBAIRN, the first of which detailed the results of experiments undertaken by him for the Association, to ascertain the relative strength of *Hot and Cold Blast Iron*.

Mr. Fairbairn's second paper was a continuation of the first, detailing the experiments made for ascertaining the strength of iron, and the best form for resistance, the results of which did not always agree with Emerson's rule. The strongest form, too, was found to differ from that given by Mr. Tredgold. Our limits will not allow us to give further details.

Of the same class as Mr. Fairbairn's papers was one by Mr. MUSHAT, on *Railway Iron*, recommending the use of iron manufactured from pig-iron by rolling, and not subjected to the refining process now generally employed, by doing away with which a much greater degree of fibre and hardness would be attained. Mr. M. had little doubt that, though at present the rails on many roads had been taken up twice or three times, yet in a short time, by the adoption of the process he recommended, exfoliation might be completely avoided.

MECHANICAL INSTRUMENTS.

A COMMUNICATION was laid before the section on a *Railway Balance Lock*, by Mr. REMINGTON, which was proposed to effect on railways what was now done by tunnels and inclined planes, and what in canals is accomplished by locks, the trains being raised on platforms by a series of levels to any required height, and the power being supplied by a stationary steam-engine, moving platforms on each side.

Mr. WILLIAMS forwarded a paper on a *Treffos Pump*, which he stated to afford considerable advantages as compared with the common pump, the principal of which consisted in the continuity of the stream of water obtained, and in the convenience afforded by being able to place the pump at a distance from the spring. As it did not, however, appear that these advantages could be anticipated with any certainty, we shall not enter further into the subject.

Mr. KINGSLEY presented a model of a *Drawing-board for Engineers*.

Mr. HAWKINS exhibited a beautiful *Bust*, copied from the antique, completely finished by a machine, a drawing of which he made for the Section. In a fixed stand were placed the chisel, and at a given distance above it a wooden chisel of the same length. Towards this stand were moved two cages, one above the other, that opposite to the wooden chisel containing the original bust, and the lower cage the marble block; these cages were capable of almost universal motion, so that the block could be applied in every part to the graver, which could never penetrate too far, being regulated by the wooden chisel above. The specimen exhibited was exceedingly beautiful.

Mr. ETTRICK showed an instrument for obtaining an *Artificial Horizon at Sea.*

Mr. WILLIS communicated a very simple and certain method of making the *Teeth of Wheels* work each other truly by taking two pitch lines, and a tracing circle of a diameter not greater than that of the smallest wheel of the set, and tracing an external epicycloid on the driving, and an internal one on the driven wheel, by which the curves would move each other exactly.

Mr. LEETHEAD communicated a paper on a *New Species of Safety Lamp*, which he believed would be found effectual when Davy's and others failed, that is, when exposed to a *current* of inflammable air. This he effected by cutting off to a much greater extent than at present the communication with the external atmosphere.

DR. CLANNING exhibited a model of a new *Telegraph*, with twenty-four letters, six being included in each round of the arm.

LIEUTENANT WATSON made some observations on the use of a *Telegraph* applied to railways, for which he was about to take out a patent.

Mr. CURTIS forwarded a paper with a model of a *Suspension Bridge*, by adopting which, inflexibility and strength would be obtained, together with a great advantage from the absence of a mainchain.

Mr. HAWKINS exhibited an instrument for measuring exactly the distance between the eyes, with a view to the *exact construction of Spectacles*, and remarked on the great difference frequently observable in the focal lengths of the eyes of the same individual. Dr. Lardner mentioned a curious fact with regard to Professor Airy's having discovered that his eyes were spheroidical, not spherical, and his having suited himself with glasses on this principle.

Under the head of MISCELLANEOUS APPLICATION OF MECHANICAL SCIENCE, comes first Mr. WEST'S paper on the *Ventilation of Tunnels*, tending to show, by a series of experiments, the results of which were given, that the usual opinion with regard to the great difference in the temperature of tunnels, as compared with the external atmosphere, was unfounded, and that shafts had little, if any effect, in altering the temperature, the air, according to Mr. West's experiments, escaping up the shaft, so that a close tunnel might be even preferable.

Mr. CURRIE made a communication on a *Safety Railway*, raised on wood.

Mr. LANG communicated a very useful method of preserving vessels from serious injury from the *loss of their keel* on rocks. His plan was to have two false keels with a solid bottom, and to caulk with Borodaile's patent felt, so that both keels might be knocked off without the leakage of a single drop of water. Mr. Lang instanced several cases, where, under the severest trials, this plan had been completely successful.

A paper by PROFESSOR MOSELEY, on the *Thrust of Arches*, was read by Dr. Lardner.

Mr. T. TAYLOR read a report on *Printing in raised characters for the Blind*, in which the Roman letters, without any abbreviations or arbitrary characters, were strongly recommended, in preference to any methods hitherto proposed. Blind children were enabled by them to read with about half the rapidity of ordinary readers. Different specimens of printing were exhibited to the section, and Mr. Alston's, of Glasgow (the one recommended), appeared to us decidedly preferable to any of the others.

PROFESSOR HENRY handed in a map of America, in which the *Canals and Railroads* now in operation and progress in that country were exhibited. There were about 2000 miles of canal, and 1500 of railway, completed, and 3000 of railway in progress.

Mr. WILLIAMS, of the City of Dublin Steam Navigation Company, described a very simple method lately adopted in their vessels for *Preventing Danger from Collision or Fire.* It consisted in dividing the vessel into five compartments by four water-proof iron bulk-heads, fitted with patent felt into the sides of the vessel, which were made, in those parts, solid for the purpose. Any of these compartments, and even three of them together, might have the water admitted to them without at all endangering the safety of the passengers or the vessel, so that in a case of collision, the injury would be merely local, and, in case of fire, the water might be freely admitted to the part where it originated, while there would be no general current of air underneath, and little danger of the fire spreading. Mr. Williams intimated, in conclusion, that one of the Company's vessels would be at the service of any of the members wishing to return to Ireland, as it had been at their disposal on their way to Liverpool.

PROCEEDINGS OF THE GENERAL COMMITTEE.

THERE were three meetings of the general committee, on the 9th, 14th, and 16th of September. Some minor arrangements were made at the first of these respecting the election of members to the general committee, but as these will be considerably modified at the next meeting of the Association, it is unnecessary to occupy our limited space with temporary regulations.

On the 14th, NEWCASTLE was unanimously selected for the next place of meeting, and the following officers chosen for the ensuing year:

President.—The Duke of Northumberland.
Vice-Presidents.—Earl of Durham, Rev. Vernon Harcourt, Prideaux John Selby, Esq.
Secretaries.—J. Adamson, Esq., R. Hutton, Esq., Professor Johnston.
Treasurers.—Rev. W. Turner, C. Bigge, Esq.

On Saturday it was announced that the Earl of Durham had declined the office of Vice-President, and that the Bishop of Durham had consented to act in his stead. From a want of a proper understanding between the local council of Newcastle and the general council of the Association, it seems that the office of President was tendered both to the Earl of Durham and the Duke of Northumberland; the latter, however, being the nominee of the general council, was approved of by the committee, and Lord Durham, believing himself slighted, declined to accept the inferior office of Vice-President.

Grants to the amount of 3057*l.* were made for the advancement of science, 1555*l.* of which were in the Physical Section alone; 1000*l.* were devoted to astronomical purposes; 175*l.* to observations on tides and waves; 150*l.* to meteorology; and 230*l.* to the construction of various instruments.

The grants to the Chemical Section amounted to 80*l.*; none of them possess any popular interest.

The amount of grants to the Geological Section was 447*l.*, the greater part of which was for the continuance of the Rev. W. Whewell's observations to determine the relative level of land and sea.

The grants to the Natural History Section amounted to 75*l.*, those to the Medical Section to 200*l.*, and to the Statistical Section to 250*l.*

The grants in the Section of Mechanical Science were—

	£.	s.	d.
For determining the strength of cast and wrought iron	100	0	0
Printing Mr. Taylor's Report on pumping engines in Cornwall	50	0	0
Extending the same investigation to other counties	100	0	0
Observations on railway constants . . .	50	0	0
Duty of one ton of coals in steam-boats . .	100	0	0
—— If the inquiry be extended to America .	50	0	0
Total of grants to Section G. . .	450	0	0

Several recommendations, not involving grants of money, were also adopted.

Public Meetings of the Association were held in the Amphitheatre on Monday, Wednesday, Friday, and Saturday. On the first of these days, the Marquess of Northampton and the Earl of Burlington addressed the members, the one on vacating, the other on assuming the Chair. Dr. Traill read a very lengthened Report of the progress of science during the last year; and the Treasurer handed in his accounts of the finances of the Association, which were in a very flourishing condition, and promised to be greatly benefited by the present Meeting.

On Wednesday a very interesting Lecture, accompanied by experiments, was delivered by Mr. SNOW HARRIS on the *Application of Lightning-conductors to Vessels.*

On Friday the Presidents of the Sections read abstracts of the various proceedings, which we have given, and on Saturday thanks were returned to the different public bodies which had opened their institutions to the members of the Association. The Town Hall was opened on the evenings of Tuesday and Thursday for a public promenade, which was fully and fashionably attended. A déjeûné was given in the Botanic Gardens, on Friday, and throughout the meeting, the utmost hospitality and kindness were exhibited towards the members of the Association, not only by the public bodies of Liverpool, but by its inhabitants individually. The number of members present on this occasion exceeded by above four hundred that of any previous year.

MISCELLANEA

New Fossil Species.

M. Eudes Deslongchamps has just published a memoir on a fossil Saurian, discovered near to Caen in 1835, which he proposes to name ***Pœkilopleuron Bucklandi***, (*q. d.* varied-ribbed). This animal, which must have been at least from 25 to 30 feet long, must have been intermediate to the crocodiles and lizards. It approximates nearly to the Megalosaurus; nevertheless marked differences in the form of the vertebræ and of the femurs, the only bones of the megalosaurus yet known to us and described, have induced M. Deslongchamps to form another genus of this new animal, characterized by the number and diversity of its ribs. These ribs are, in fact, of different sorts; there are seven, symmetrical, curved like a chevron in the middle, and tapering off at their two extremities, at which their upper surface is channelled out. They were evidently placed on the medial line, in the thickness of the coatings of the abdomen, and resemble the osseous spines which are found in the abdominal muscles of certain lizards, as chameleons, the anoliæ, &c. The Pœkilopleuron had seven other pairs of ribs, or fourteen osseous parts, resembling, to a certain degree, the former, and which also must have been situated among the muscles behind the former, but with this difference, that instead of being united on the median line into one, they were united by means of ligaments. All the abdominal ribs were provided at their extremities with a bony process on the inner face, and attached, for about half their length, in the channel beforementioned. The seven last pairs of ribs, with their processes, resembled nearly the smaller ribs of the crocodiles.

It would appear from this singular formation, that the inferior portion of the abdomen must have been very extended, and that it must have been fortified with forty-nine bony pieces.

The other portions collected and collated by M. Deslongchamps are caudal vertebræ, to the number of twenty-one, a great number of ribs, a pelvis, a femoral bone, a portion of the fibula, four bones of the tarsi, many phalanges, a left humerus, radius, and cubicular bone. The vertebræ have the body slightly concave, both before and behind, and present characters which assimilate them with those of crocodiles and of lizards, without belonging to either of these types.

Method of transporting Exotic Plants.

[The following clear account of the method of transporting exotic plants from distant countries in a living state, proposed by N. Ward, Esq., of Wellclose-square, is translated from the instructions written for the expedition in the *Astrolabe* by M. de Mirbel, and will serve to elucidate the somewhat meagre report made on this subject at the late Liverpool meeting.]

Another apparatus for the carriage of plants, invented by Nathaniel Ward, Esq., of London, presents a still greater chance of success than that of Luschnath*; but it only fulfils its object, provided it remains exposed to the full action of light during the voyage, and is not too much shaken. This apparatus consists in a long box, surmounted by a glazed roof, formed of two frames, adjusted so as to meet at an acute angle. The two ends of the box extend two or three inches below the bottom, and serve as feet to the apparatus, and are also continued above the sides, and are formed into an acute angle, to close the ends left open by the sloping roof. One of the frames is fixed, the other is secured in its place by screws, and may be removed at pleasure, but it should be made to close the box accurately as long as the voyage lasts, for this perfect air-tightness of the apparatus is essential to success. The frames are divided into compartments for glazing by bars, half an inch broad, and 1½ to 2 inches apart, the glass being in small pieces, very thick, and closely joined together with mastic at the overlaps.

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* Thus in original; it is the name of an English gardener, but there must be, as usual, *some strange* mistake in the spelling.

To prepare this chest, the moveable light is taken out, and the bottom of the box covered to a depth of half an inch or more, with moistened, well-tempered clayey earth, hard beat down, but not decidedly wet. On this substratum is laid earth of a good quality *, neither too stiff or too light, but well mixed. The plants are placed in this soil, some with their roots naked, others having a clod of their native soil attached, which clod should be bound up in dry moss with bass or packthread, and some in pots buried in the earth.

Thus arranged and left to themselves, the plants secured from drought or humidity, will travel for long periods, undergoing changes of latitude and climate, without being sensibly affected in their health. They are, in fact, in a torpid state during the voyage, and their nutrition and exhalations seem to be equal, respiration continues, and the herbaceous parts preserve their colour, but they do not sensibly increase in size.

For some years past, interchanges of plants made on this plan between Calcutta and London, have succeeded beyond all hopes. The Messrs. Loddiges, who possess at Hackney the richest nursery in Europe, are continually sending out to New Holland, Van Diemen's Land, the East Indies, &c., empty boxes of this description, which are returned to them full. The administration of the *Museum de l'Histoire Naturelle* has just received, for the first time, one of these chests, for which it is indebted to the enlightened courtesy of Dr. Wallich, director of the botanic garden at Calcutta. This box contained fifteen precious species, which hardly appeared more exhausted than the plants taken out of our frames on the return of Summer, and yet the voyage must have lasted eight or nine months. The administration sent Dr. Wallich, in return, in a box made on the same plan, plants from the south of Europe, and from the hot regions of America; and, following the example of the Jardin du Roi, the family Cels, whose hereditary zeal for the introduction of exotic plants into France is known to all the world, has also forwarded another case to Dr. Wallich similarly furnished.

New Compound.

M. REGNAULT has recently paid attention to the action of anhydrous sulphuric acid upon bicarburetted hydrogen, and has detected a new isomeric compound of sulphovinic acid. If bicarbonated hydrogen and anhydrous sulphuric acid are mingled in a tube of a V form, the combination is attended with a considerable elevation of temperature, and the formation of a white crystalline matter, which is deposited on the sides of the tube; but it is essential that the gas should have been purified by being first passed through a solution of potassa, and subsequently through several vessels of concentrated sulphuric acid.

The crystallized matter thus obtained melts at 80°, and consolidates again on cooling; it dissolves readily in water, and the solution is strongly acid. An abundant soluble salt is obtained by saturating the liquid with carbonate of barytes; this salt crystallizes in small semi-transparent indeterminate scales. It loses nothing in weight by drying, and is only decomposed at a temperature above 200° Reaumur.

Analysis shows that this salt is formed of 10 atoms of hydrogen, 4 atoms of carbon, 1 atom of oxygen, 1 atom of barytes, and 2 atoms of sulphuric acid. This compound is identical with that of the sulphovinate of barytes; but since the salt under consideration does not contain any water of crystallization, it must be regarded as the isethionate of barytes already announced by M. Liebig. The salt of copper crystallizes in irregular octohedrons of a very pale green; that of potassa in brilliant scales, like chloride of potassa.

The composition of these salts demonstrates that there is just 2½ times more barytes in combination with isethionic acid than with sulphuric acid; and since isethionic acid contains 2 atoms of sulphuric acid, it may be concluded that of 6 atoms of sulphuric acid placed in contact with olefiant gas, 5 atoms combine with this gas, and 1 is liberated, and, what is more, remains in a great measure in the anhydrous state, for the matter gave out vapours abundantly. From this it is evident, there is a simple combination between the olefiant gas and the anhydrous acid, and that there has taken place no reaction similar to what happens in the formation of sulphobenzic and sulphonaphthalic acids, in which there is always a production of hydrated sulphuric acid. Anhydrous sulphuric acid, therefore, combines directly with bicarburetted hydrogen, but when redissolved in water, it takes an atom of water, and becomes isethionic acid, by appropriating its elements and totally changing its nature.

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* It should be peat or bog earth.—(*Editor.*)

The manner in which bicarburetted hydrogen acts with anhydrous sulphuric acid appears to throw a light on the theory of ethers, and every one must be struck with the analogy which olefiant gas presents with ammoniacal gas. We know, in fact, from the beautiful experiments of M. Henri Roze, that dry ammoniacal gas combines with anhydrous acids,[1] and forms compounds essentially different from the corresponding ammoniacal salts, but which, taken up again in water, immediately transform themselves into ordinary ammoniacal salts, so that the ammoniacal gas takes up an atom of water and becomes oxide of ammonium. Olefiant gas acts in precisely the same manner, and when in the presence of water, appropriates its elements and becomes oxide of ethyle, which may afterwards pass into all the etheral combinations.

Isethionic acid ought therefore to be considered as a compound of oxide of ethyle and of sulphuric acid, and would, consequently become isomeric with sulphovinic acid, while M. Liebig is induced to consider it as a compound of hyposulphuric acid with ether, having lost two atoms of hydrogen.

Isethionic acid is not the only acid which is isomeric with sulphovinic acid, for, without reckoning the ethionic acid of Magnus, about which there is still some uncertainty, there is another sulphovinic acid formed by the reaction of concentric sulphuric acid upon alcohol and on ether. This acid is easily distinguished from ordinary sulphovinic acid, by the form of its crystals and the properties of its salts. This new acid, which M. Laurent calls althionic acid, is obtained by heating alcohol with an excess of sulphuric acid.

The Odour of Wines due to a peculiar Ether.

"It is a fact of common observation, that a bottle containing but a few drops of wine, gives off a peculiar odour, which cannot be imitated by mixing alcohol and water in the proportions in which they exist in the wine. This characteristic odour, which is more or less apparent in all wines, is produced, according to MM. Liebig and Pelouze, by a fluid possessing all the characters of an essential oil. The flower, aroma, or *bouquet* of wine, as it is more especially called, is produced by a substance which is inodorous, and should not be confounded with the subject of these remarks; it is not volatile, is different in the several kinds of wines, and in many fails entirely.

"This oil may be obtained by distilling large quantities of wine, or the lees of wine, or especially from the product deposited after fermentation has commenced. From the results obtained they infer that this oil constitutes about $\frac{1}{40000}$ part of the wine. The oil as thus obtained, before purification, has a strong odour, and is generally colourless. Occasionally it presents a slightly greenish tint, derived from the presence of a small quantity of copper, as is proved by reagents; this colour may be removed by distillation.

"The constitution of this product, though it contains a considerable quantity of oxygen, is quite different from that of the oxygenated essential oils heretofore known. It proves to be a peculiar ether containing an acid allied to the fatty acids. This new acid is called by its discoverers *œnanthic acid*, and the ether, consequently, *œnanthic ether*.

"*Œnanthic Ether.*—The œnanthic ether may be deprived of any free acid it may contain, by agitation with a hot solution of carbonate of soda, and subsequently boiling the mixture; the ether rises to the surface and may be readily removed. The small quantity of water or alcohol which it still retains, may be separated by means of the chloride of calcium. The ether thus purified is very fluid, similar to the essential oil of mustard. It is colourless, has an extremely strong odour of wine, which, when respired, is almost intoxicating. Its taste is very strong and disagreeable. It dissolves readily in ether and alcohol, even when the latter is quite dilute; yet it is not sensibly soluble in water. Its density is 0·862, and is but slightly volatile. It boils between 225° and 230° C.

"In three analyses MM. Liebig and Pelouze obtained the following results:—

Carbon	71·815	72·50	72·02
Hydrogen	11·844	11·86	12·05
Oxygen	16·341	15.64	15·93

which correspond very nearly with the formula $C^{10}\ H^{36}\ O^{3}$. The œnanthic ether is readily decomposed by the caustic alkalies. With potassa it affords a very soluble compound, consisting of œnanthic acid and potassa. When this salt is decomposed by sulphuric acid, the œnanthic acid forms an oily bead on the surface of the liquid.

"*Œnanthic Acid.*—This acid presents a butter-like consistence at a temperature of 13·2° C. and is of a white colour; at a higher temperature it melts, and forms a colourless inodorous oil, which reddens tournesol, and unites readily with the caustic alkalies and alkaline carbonates. The œnanthate of potash is a pasty mass, composed of extremely fine fibres, which present a silky lustre after desiccation. From the composition of the œnanthates of lead and silver, the authors infer that two atoms of base saturate three of acid.

"In three analyses, MM. Liebig and Pelouze obtained for the hydrated acid,

Carbon	69·28	69·74	68·59
Hydrogen	11·54	"	11·56
Oxygen	19·18	"	19·85

which lead to the formula $C^{14}\ H^{28}\ O^{3}$. The anhydrous acid afforded carbon 74·32, hydrogen 12·2, oxygen 13·58, which corresponds with the formula $C^{14}\ H^{26}\ O^{2}$. It may hence be inferred, that œnanthic ether is composed of œnanthic acid united to common ether, as is represented in the formula $C^{14}\ H^{26}\ O^{2} + C^{4}\ H^{10}\ O$, in the construction of which, and also in the preceding deductions, Berzelius's atomic weights have been used.—*Ann. de Ch. et de Phys.* Oct. 1836.

Spots on the Sun's Disk.

For upwards of a twelvemonth past, this remarkable phenomenon has been observed to be on a greater scale than there is any existing record of its having been in former times. M. Struve, in a letter to M. Schumacher, observes:—"In July, 1836, very large spots were observed on the sun. I had only an opportunity of seeing them myself once, and then with a telescope of low power, but I never remember seeing so extensive a group. My son Otto pointed out to me that they might be distinctly recognized with the naked eye, through a coloured glass;—a fact, I believe, that has not been witnessed for a long period." (See also No. XX. p. 155.)

Composition for Leather, for Straps for Gearing, and for other purposes.

"The method taken to make them run light and slack without slipping, was as follows; and the plan succeeded so well, that every manufacturer who uses belts, ought to know it.

"I prepared my belts by stuffing them, after they were completed, with a composition of common tallow, bayberry tallow, and beeswax, in the following proportions, viz:—two pounds of common tallow to one pound of bayberry tallow, and one pound of beeswax.

"I melted the ingredients in a kettle placed over a furnace of charcoal, and heated the composition to the boiling point, and kept it boiling while applying it to the belts. I put it upon both sides of my belts with a brush, the leather being perfectly dry; and notwithstanding the composition was so hot, the wax did not strike into the belt, but a great proportion of it was left on the surface. I then filled a small iron box-stove with charcoal, and set it on fire, and when the stove was at nearly a red heat, I moved the belts slowly over the top, and within half an inch of the stove, and by this means heated the leather so as to cause the wax to strike into it. I was at first apprehensive of burning the leather with the degree of heat applied, but I have since found that there is not the least danger of it if the leather is perfectly dry.

"To test the degree of heat the dry leather would bear without burning, in the composition, I placed a kettle of it over a blacksmith's fire, and after melting it, I put in a coil of two-inch belting, about sixteen feet long, and boiled it forty-five minutes with the greatest degree of heat I could produce by blowing the fire continually, and the belt, when taken out, was not in the least injured by the heat of the composition. I then tried a piece of belting damped with water, and it burnt and crisped in less than half a minute.

"I have found that, by stuffing belts in this manner, I could work up my stock much closer, for the composition enters into and fills up the thin, porous, and spongy parts of the leather, and renders them nearly as firm and durable as the best of the leather cut from the back of the hide.

"In many mills a practice prevails which is very injurious to the durability of the belts, and ought to be abandoned. That is, the practice of applying curriers' oil, or neats'-foot oil to the belts, to prevent them from slipping; for the oil opens the pores of the leather, destroys the adhesion of its parts, and, in a very short time, renders it flaccid and rotten, and a belt will not last half so long stuffed with oil as with the composition before named. The experiment is easily tried, and it will prove to any one's satisfaction the truth of this statement.

"I am of opinion that engine hose is frequently destroyed more by the use of neats'-foot oil than by time and use, and that its durability, generally, might be greatly prolonged if the leather were stuffed with wax and tallow before it is made up, and then occasionally applied after it is put into use.

"There are other advantages in the use of this composition: it not only preserves the leather, and keeps it firm, and at the same time flexible, and perfectly pliable, but it does not require half the expense of time in the application that oil does; for belts stuffed with the composition will run well for six months without glazing so as to need a new application.

"This composition is impervious to water, and, on that account, is an excellent article for boots and shoes, as well as for engine hose.

"I once tried the experiment with a pair of boots, made of a calf-skin curried and finished without a particle of unctuous matter of any kind; and after the boots were made I stuffed them in the same manner that I do my belts (with the addition of a little ivory black to the composition), and roasted them by a fire until the leather, both soles and tops, was completely saturated; and there never was a particle of oil applied to them, and they were always impervious to water, and their durability exceeded any boots I ever wore."—*Journal of Franklin Institute.*

New Scientific Society.

THE science of Electricity has been raised to such importance by the discovery of the exhaustless store of phenomena it presents, and their intimate connexion with physical action of all kinds in nature, that it has long deserved to be cultivated by a society, in the same way as Astronomy, Geology, Geography, Natural History, Statistics, &c., have been for some time past in this country. Accordingly, a few scientific persons, who met together to prosecute experiments in the various departments of electricity, have instituted a Society for that purpose, which promises soon to take its place with its elder sisters just alluded to.

The *Electrical Society of London* will hold their meetings, by permission of the Council of the Society for the Encouragement of Practical Science, in the Lecture-Room of that Institution in Adelaide-street; and it has already enrolled among its members, gentlemen thoroughly conversant with the subject *it professes to* investigate. With the resources of an infant establishment, generously and warmly supported, added to those placed at its service by the celebrated Institution above-mentioned, the scientific world may expect considerable enlargement to the sphere of our knowledge of this omnipotent agent, from the exertions of this new society.

Singular Evolution of Sulphuretted Hydrogen from a Well near Ware.

"THIS well was dug in 1833, in the premises of Mr. Munt, a magistrate of the county, and the information respecting it obtained from two gentlemen accustomed to collect evidence with the strictest scrutiny.

"The strata passed through were, one foot vegetable mould, 15 feet gravel, one foot sand with flints, 83 feet gravel clay, 15 feet blue sand with black pebbles, 10 feet blue clay, 1½ feet fine soft white sand, or 126½ feet down to the chalk, which was penetrated for 40 feet when a spring was met with; but the digging continued 17 feet lower to form a reservoir of water, and this was favoured by making the excavation in the chalk of a bell shape, but above this, the well was 4½ feet in diameter.

"When the well was dug the weather was dry, but on this becoming very wet, the 15 feet stratum of blue sand and black pebbles began to emit foul air, by which one of the well-diggers was suffocated in descending. A hawk flying over the well fell into it, and a similar fate befell smaller birds, also wasps, bees, and flies. On closing up the mouth of the well, with the exception of an orifice an inch in diameter, so powerful was the force of the issuing current of foul air, that it raised a weight of twelve ounces of lead. In fine weather there was, on the contrary, a strong draft down into the well.

"Eight months afterwards the well was again entered, when the stratum of blue sand and black pebbles appeared forming into plum-pudding stone. The well was rendered safe by bricking it down to the chalk, applying a thick coating of compost over the whole. Dr. Mitchell explains the phenomena, by observing, that the foul air was no doubt sulphuretted hydrogen, produced by the decomposition of water and iron-pyrites. After long-continued rain, water penetrating into the bed dislodged the gas accumulated in the interstices where it was formed; while, after dry weather had continued for some time, the openings produced in this bed on drying up, would draw, for a short time, a supply of air to fill up the vacuities, and hence the draft observed to pass down into the well. The whole of the neighbouring district, to the extent of four miles, is called by the well-diggers, foul country. Similar phenomena were observed in digging a well on the opposite hill at Applebury, and also in forming some wells in the immediate vicinity of London."—*From a paper read at the Geological Society, in May.*

Atomic Constitution of Dextrin.

M. PAYEN has succeeded in determining the atomic constitution of Dextrin, and in showing that this substance, which is fecula in the first degree of disintegration, is isomeric with the sugar from the sugar-cane. Dextrin acts on polarized light, causing the plane of polarization to turn to the right, whilst sugar from the grape, into which it is easily converted by the action of acids and other reagents, turns this plane to the left.—*Echo du Monde Savant*, 9th of August.

Tide in the Euripus.

MANY travellers have mentioned the tides of the Euripus, but no one has made a set of connected observations by which the law of this tide (or current) may be ascertained; accordingly there is little agreement between the different accounts of the phenomenon. Some state that the current flows twice each day in one direction, and twice in the other, as with ordinary tides; and others question the existence of the current altogether. The ancients have recorded that there were seven floods and seven ebbs daily. In the Travels of Spon and Wheler, there is a letter from a Jesuit, *Jacques Paul Barbin*, who, it is stated, observed the currents of the Euripus during two years. According to Barbin, the tide of the Euripus is regular for eighteen or nineteen days in each lunation, and irregular during the other eleven; in which period it would flow eleven, twelve, thirteen, or fourteen times in one direction, and as much in the contrary direction consecutively. He states having seen the current change three times in an hour and a half.

During the days of irregular tides, the current, according to the same authority, flows for half an hour, and ebbs for three quarters, the tide rising ordinarily about a foot, and rarely two. The flood happens when the current sets to the south, and the ebb when it sets in the contrary direction, and between the two there is an interval of repose. Barbin further states that the tide of the Euripus is regular during the three last days of the lunation, and up to the eighth day of the new moon, irregular up to the 13th day inclusive, then regular from the 14th to the 20th day inclusive, irregular again from the 21st to the 26th, regular the 27th, and so on.

The information which M. Peytier has obtained does not accord with the statement of Père Barbin; according to this information the tides in the Euripus would be always nearly regular; and the current flows from three to four hours in each direction alternately, which would indicate a double tide, to which violent winds would give occasional irregularity.—*Echo du Monde Savant*, 9th of August.

Experiments on Electro-Magnets.

"THE following experiments were made for the purpose of ascertaining the best method of constructing electro-dynamic magnets by means of coils of metallic ribbon.

"1. A horse-shoe of soft iron, twenty-four inches long, and one inch in diameter, was wound with a single covering of zinc ribbon covered with silk. When the extremities of the zinc were immersed in the cups of a small galvanic battery containing only eighteen square inches of zinc, a considerable degree of magnetism was induced in the iron.

"2. A ribbon of zinc, one inch in width, and twenty-four feet long, was wound around the same iron in small coils of four in thickness each, and succeeding each other, the whole length of the iron. The effect in this experiment was greater than in the last, but not as great as I had reason to expect.

"3. The same ribbon used in the last experiment was wound singly around the iron, and then back again, covering the iron in this way with four thicknesses of the zinc, and winding in the same direction the whole time. Upon applying the battery, the induced magnetism was less than in the first experiment. As the ribbon was wound in the same direction the whole time, so the tangential direction of the revolving magnetic force in each layer of the zinc tended constantly towards the same pole of the temporary magnet,—the result was unexpected. But it was, doubtless, owing to the oblique direction of the covering, and which obliquity in the contiguous layers was in an opposite direction. As the ribbon was one inch in width, and the iron one inch in diameter, the angle at which the layers crossed each other was more than 45°.

"4. The whole horse-shoe was then wound with the same ribbon singly, and that which was left after covering it, was then coiled spirally upon one extremity of the iron. A strong magnetic action was now developed in the iron, much superior to that shown in any of the preceding experiments. The pole supporting the spiral coil was much superior in power to the other.

"5. The iron horse-shoe was then covered with one hundred and thirty feet of the same ribbon. This was wound singly over the whole iron, and a spiral coil around each pole, the two spirals being coiled in different directions, and one containing about twenty-five feet more than the other. This arrangement showed considerable magnetic power, but not quite as much as the last. The two coils being wound in different directions, nearly neutralize each other, and the only power gained is that produced by the excess in the length of one coil over the other.

"6. The same ribbon used in the last experiment was coiled in two spirals, one around each pole of about equal size, and wound in the same direction, and having the extremities of the ribbon in the centre of each coil respectively.

This produced the most powerful effect yet experienced, as the apparatus with the small battery of eighteen inches, and very feebly charged, was capable of raising fifty pounds.

"7. The whole apparatus was disposed as in the last experiment, only that the extremities of the ribbon in one coil proceeded from the centre, and in the other from the circumference. This produced the most powerful effect of all, and with the same battery raised nearly twice the same weight.

"8. If the whole apparatus be arranged as in the last experiment, and another coil be placed upon the extremities of the iron, taking care that the current run in the same direction in both coils, upon connecting this with the same battery as the other coil, the power of the magnet will be greatly increased.

"It must appear evident to every one, that the power of these magnets may be increased *ad infinitum*, by increasing the size of the horse-shoe of soft iron, by increasing the width and length of the metallic ribbons, and also increasing the power of the battery. The effect may be considered as similar to that of a number of wires wound in the same direction, whose surface is equal to that of the ribbon. The labour of constructing a magnet of any size upon the old plan, by winding an iron with a number of wires, is very great; but a magnet constructed upon the plan mentioned above, may be made in a few hours.

"The expense of construction is also vastly diminished, and this, not only by diminishing the labour, but also the cost of materials; and as the power of the magnet may be increased to an unlimited extent, it must be preferable in every respect to those constructed with wires."—*Silliman's Journal.*

Another Instance of the Economy of Nature for the Regulation of Species.

THE excessive increase of the *Scolytus destructor* having compelled the cutting down of a large number of elms at Brussels, during the Spring of last year, M. Wesmael, when examining numerous fragments of the bark furrowed by the larvæ of these insects, found abundantly in these cavities small brown cocoons from two and a half to three lines in length, evidently belonging to some pupivorous hymenopteral insect. Accordingly, about six weeks afterwards, the *Braconius initiator*, male and female, were hatched from these cocoons. It appears, therefore, from these observations, that the Braconius deposits its eggs in the bodies of the larvæ of the Scolyti, and by thus destroying them, renders an important service (?). To fulfil this function, the females have the abdomen terminated by an ovipositor as long as their bodies. Towards the close of last Summer, M. Wesmael had an opportunity of observing many of the females slowly traversing the trunks of the old elms. Although divided from the larvæ of the Scolyti by the whole thickness of the bark, the Braconius, by an admirable instinct, ascertain the precise place where the larvæ are situated, and then taking advantage of some fissure they introduce their long ovipositor, which is flexible in all directions, and deposit an egg in the body of their victim.—*Echo du Monde Savant*, 12th of August.

Comparison of the measured Meridian Arcs.

ACCORDING to M. Bessel, Walbeck is the first astronomer who endeavoured to connect the results of the various measurements of arcs of the terrestrial meridian which appeared most to be relied on, for the purpose of deducing a determination of the axes of the elliptic spheroid of revolution. But he only paid attention to the extreme points of each measured arc, and omitted all consideration of the intermediate ones, even when they had been determined astronomically. Dr. Edward Schmidt has completed these calculations, by allowing the same importance to all the observed altitudes of the pole, and taking into account all the subsequent measurements of degrees up to 1831.

M. Bessel has himself recently taken up this subject in the 333 No. of the *Astron. Nachrichten*, correcting some of the data employed by Schmidt, and introducing into the calculations the results of three new measurements of degrees. The first of these has been communicated to M. Bessel by the Russian General De Tenner, who effected it between Belin and Jacobstadt, connecting his northern part with the measurement of M. Struve in Esthonia, so as to produce by the conjunction an arc of the meridian of 8° 2′ 29″. The second has been accomplished in Denmark, by M. Schumacher, and comprises between Lauenburg and Lysabbel an arc of 1° 31′ 53″. The third was effected in the neighbourhood of Königsberg, by the Prussian Major Bäyer, and, comprises an arc of 1° 30′ 29″ from Truny to Memel. These three measurements joined to those in Peru, the two in Bengal, (the second of which has been recalculated by M. Bessel, and embraces an arc of nearly 16°;) to the great French measurement from Dunkirk to Formentera; to the English measurement from Dunnose to Clifton; to that executed by M. Gauss in Hanover, and lastly, to the measurement in Lapland, adopting the results of Svanberg, constitute the elements on which M. Bessel has based his calculations.

Not being able to enter now into the details which he gives of the relative values of each admeasurement, or into the analytical developement and numerical application of the method he has followed, we shall content ourselves with reporting the results at which he has arrived.

The values of the two terrestrial semi-axes which he has obtained, in French toises of six royal feet, are—

$a = 3271953 \quad = 21472191 \cdot 5$ English feet.
$b = 3261072 \cdot 9 = 21400790 \cdot 9$ Do. do.

and the formula $\frac{a-b}{a}$ gives the compression in terms of the semi-major axis $\frac{1}{300 \cdot 728}$, while that of M. Schmidt was $\frac{1}{309 \cdot 036}$.

The length of the mean degree of latitude obtained by M. Bessel is 57011·453 toises, with a probable error of + 2·9 toises. M. Schmidt had obtained this length 57008·715, the error probably 3·9.

By comparing the observed latitudes at each station with those obtained from the elliptic spheroid which most nearly corresponds to their aggregate, M. Bessel has found discrepancies which amount to a few seconds, sometimes in one, sometimes in the opposite direction, and these may arise from local causes. The mean value of these discrepancies amounts to 2″·695, that determined by Schmidt was 3″·067. Thus the three new measurements introduced by M. Bessel have produced a spheroid which appears to agree better than M. Schmidt's with the aggregate of observations.—*Bib. Univ. de Geneve*, July, 1837

German Metaphysical Physiology!

"As the plant may be considered a crystal continually developing itself in a constant change of its matter, in like manner the living animal body so nearly represents a plant which has reached a higher unity and faculty of self-determination, that although the animal still remains a part of a higher unity, and is closely bound to the earth by the necessities of life, yet this hold taken of the animal as compared with that taken of the plant, is even less in degree than that which we observe in the plant as compared with the unorganized body. For this very reason, the animal presents, among natural bodies, the most perfect idea of an organism; and as we can prove mathematically that there are only three fundamental numbers (which are continually repeated in all forms of perception, namely, unity, its division into duality, and the reunion of the unity and duality in trinity), which are exemplified in our conception of space through the three-fold dimension of length, breadth, and thickness,—in like manner, the three-fold succession of inorganic vegetable and animal life exhibits the members which together afford the idea of an organism, viz., multiplicity, developement, and unity.

"A third consequence of the above is, that the animal being the realization of the abstract idea of unity, in which all parts must relate to a common centre, the sphere must be of necessity the original type of animal organization, the *globe being that* which tends to its centre with perfectly equal relations (radii).

But, so far as the animal is not merely the upper part of the plant become detached, but likewise contains in itself the organs of the root, the globe must be hollow, and contain within itself the intestines, which can be most clearly pointed out in the lower animals. Because, without taking into account that the Infusoria appear merely as so many living hollow globules or cells, this kind of structure is evident in the bladder-worm (Cysticercus), in which the absorbing proboscis (therefore called the head) is in reality curved inwards into the cavity of the body, exactly in the manner described in the hypothetical metamorphosis of the plant into an animal. Similar forms are also exhibited by the Echinus tribe, to which we must add, that microscopical observations show most clearly that the whole of the organic mass of higher animals is composed of minute globuli.

"We have now further to consider the composition and internal formation of the animal body, as well as the nature and direction of its active faculties of life. In the first point of view, we observe that it contains, like the organism of the earth and of the plant, a combination of solids, fluids, vapours, and gases, among which the fluids are again the sources of the rest. Its ultimate elements are principally hydrogen, oxygen, and carbonic acid gas, with the additional one of nitrogen, which peculiarly belongs to this kingdom, and the volatile nature of which perfectly agrees with the rapid merging of animal bodies in the universal life of nature, as soon as their individual life is extinct; to which passage, however, the earthy parts, such as bones and shells, offer somewhat longer resistance. In regard to the internal formation of the solid parts of the animal body, it has been already remarked that the spherical type, in so far as it is peculiar to animal forms in general, is also visible in the basis of all animal matter, so that the molecular substance is the basis of the collective animal body. If we now reflect likewise how in the Infusoria and Priestley's matter, the rudiments of the animal kingdom appear as so many animated globuli, we shall thence perceive that the largest animal bodies themselves must be viewed as an innumerable aggregate of Infusoria, but at the same time united into a living whole."—CARUS *on the Kingdoms of Nature.* From the *Scientific Memoirs.*

Movement of our System in Space.

"M. ARGELANDER has lately laid a valuable memoir before the Academy of St. Petersburg, in which he has proved beyond all doubt the fact of the general motion of our solar system towards a point very near to that which had been fixed on by Herschel, that is, towards a point situated in the constellation Hercules, in 260° 50′ AR., and 31° 17′ north declination. This conclusion is deduced from the proper motions of 390 stars, of all of which this motion exceeds 0″·1 annually. This is one of the fruits of the brief existence of the observatory at Abo, and is founded on the excellent catalogue of 560 stars, published by M. Argelander in 1834."

Magnetism audible!

"A LONG copper wire, covered with cotton, was wound tightly into a flat spiral. After making forty turns, the whole was firmly fixed by a smearing of common cement, and mounted vertically between two upright supports. The ends of the wire were then brought down into mercury cups, which were connected by copper wires with the cups on the battery, which was a single pair of zinc and lead plates, excited by sulphate of copper. When one of the connecting wires was lifted from its cup, a bright spark and loud snap were produced. When one or both poles of a large horse-shoe magnet are brought by the side, or put astride the spiral, but not touching it, a distinct ringing is heard in the magnet, as often as the battery connexion with the spiral is made or broken by one of the wires. Thinking that the ringing sound might be produced by agitation or reverberation from the snap, I had the battery contact broken in a cup, at considerable distance from the field of experiment; the effect was the same as before. The ringing is heard both when the contact is made and broken; when the contact is made the sound emitted is very feeble; when broken it may be heard at two or three feet distance. The experiment will hardly succeed with small magnets. The first used in the experiment consisted of three horse-shoes, supporting ten pounds. The next one tried was composed of six magnets, supporting fifteen pounds by the armature. The third supported two pounds. In each of these trials the sounds produced differed from each other, and were the notes or pitches peculiar to the several magnets. If a large magnet, supported by the bend, be struck with the knuckle, it gives a musical note; if it be slightly tapped with the finger-nail, it returns two sounds, one its proper musical pitch, and another an octave above this, which last is the note given in the experiment."—(*From a letter to Dr. Silliman from Dr. Page of Salem.*)

New Coal Beds.

An extensive coal-field has recently been discovered in the Department of the Saone and Loire, which promises to prove one of the largest in the kingdom; it is situated in the valley Arroux, about a league from Autun.—*L'Echo du Monde Savant,* Aug.

Productiveness of the Siberian Mines.

M. Humboldt has shown, in a letter inserted in the *Annalen* of Poggendorff, that the production of gold in the Altai mines of Siberia has increased more than a hundred fold-during the last seven years. In fact, this production in 1829 was 1 pood or 40 Russian lbs., and in 1836 it amounted to 104 poods 15 lbs.

The produce of the Ural mines in platina has remained stationary since 1829, varying between 115 and 119 poods.

The gold mines of the Ural appear to have yielded a decreasing produce for some years past. In 1832, they furnished 364 poods 19 lbs., and in 1833 340 poods 34 lbs.; subsequently it fell to 309 poods in 1834; and it has only been 292 and 293 poods in the two last years.

The Russian government, all the views of which are directed to the augmentation of its financial powers, and which finds in the gold mines of its own soil the most fruitful element of its wealth, has just published in the *Commercial Gazette of St. Petersburg,* a statement of the important discoveries recently made, relative to the working of auriferous sands, which statement we shall here give in substance.

"The Minister of Finances gave directions last year for a series of experiments on the net produce of auriferous sand, according as the processes of washing, amalgamation, or chemical action, were respectively adopted. Colonel Anossoff, of the corps of Mining Engineers, while making these experiments, conceived the happy idea of melting the sand to produce iron from it, it being concluded that gold is only found with oxide of iron, mixed with other mineral debris constituting the sand in question. The principal results of these experiments, compared with the old methods, have been, that amalgamation produces eight times more gold than washing; the *wet-way* by the action of acids ten times more; and the melting of 2800 feet of sand, in order to extract the iron, has yielded twenty times more gold."

These experiments have, in consequence, been ordered to be repeated at other gold works throughout the country.

The Planet Pallas.

M. Lamont, by means of the great telescope at Bogenhausen, has determined the diameter of the planet Pallas. With a magnifying power of 1200, he has found the diameter, reduced to the planet's mean distance, to be $0''\cdot51$, which is equivalent to 145 German miles, or 242 leagues of 25 to the degree. It will be seen that this magnitude is intermediate to those assigned by Herschel and Schröter.

The same savant has also discovered, with the aid of this powerful instrument, two clusters of stars, one situated in the Shield of Sobieski, the other in Perseus; he has laid down a chart, and determined the relative positions of the stars which compose them.—*Bib. Univ. de Geneve,* July, 1837.

Patent-Law Grievance. No. XIX.

THE inventors of this country, and the introducers of inventions of other countries into this, were obliged to pay down to the attorney-general and other agents, &c., of the Government, during the ten years ending December, 1834, more than £313,000, and during the past year above £42,000 (being at the rate of £420,000 in ten years.) It is to be observed that these enormous extortions are *exclusive* of the drawings, engrossings, and all the other charges of the patent-solicitor.

The penalties inflicted on the inventive genius of Britain during the *present* year, up to the 25th ult., in the shape of government stamps and fees on patents, amount to more than £30,000!

N.B. This sum has been paid in *ready money* on taking the first steps, and as many of the inventors are poor men, (*Operatives,*) and a great many others of them persons to whom it would be very inconvenient to pay at least £100 down, they have been obliged to go into debt, or mortgage or dispose of their inventions, either wholly or in part, &c.

NEW PATENTS. 1837.

N. B.—The first Date annexed to each Patent, is that on which it was sealed and granted; the second, that on or before which the Specification must be delivered and enrolled.——The abbreviation *For. Comm.*, signifies that the invention &c., is "a communication from a foreigner residing abroad."

AUGUST *contd.*

157. WILLIAM ARMSTRONG, Junior, Hawnes, *Bedford*, Farmer; for improvements in ploughs. Aug. 28.—Feb. 28.

158. JOHN JOSEPH CHARLES SHERIDAN, Ironmonger-lane, *Lond.*, Chemist; for improvements in the manufacture of soda. Aug. 31.—Feb. 28.

159. JOHN HANSON, Huddersfield, *York.*, Leaden Pipe Manufacturer, and CHARLES HANSON, of the same place, Watch Maker; for improvements in machinery or apparatus for making or manufacturing pipes, tubes, and various other articles, from metallic and other substances. Aug. 31.—Feb. 28.

160. JAMES NEVILLE, Clap Hall, near Gravesend, *Kent*, Civil Engineer; for apparatus or furnace for economizing fuel, and for more effectually consuming the smoke or gases arising therefrom; the same being applicable for the generation of steam, and for heating or evaporating fluids. Aug. 31.—Feb. 28.

TOTAL, AUGUST...17.

SEPTEMBER.

161. WILLIAM JAMES GIFFORD, Gloucester-place, *Middx.*, Surgeon; for improvements in paddle wheels. Sept. 7.—Mar. 7.

162. HENRY VERE HUNTLEY, Great Russell-street, *Middx.*, Lieut. in the Royal Navy; for improvements in apparatus for facilitating the securing of ships' masts. Sept. 7.—Mar. 7.

163. THOMAS JOHN CAVE, Rodney-street, Pentonville, *Middx.*, Gent; for a great improvement in the construction of paddle wheels, applicable to ships, boats, and vessels of all descriptions, propelled by steam, or other mechanical power. Sept. 14.—Nov. 14.

164. EDMUND SHAW, Fenchurch-street, *Lond.*, Stationer; for an improvement in the manufacture of paper, by the application of a certain vegetable substance not hitherto used for that purpose. Sept. 14.—Mar. 14. *For. Comm.*

165. RICHARD DAVIES, Newcastle-upon-Tyne, and ROBERT CHRISSOP WILSON, Gateshead, *Durham*, Earthenware Manufacturers; for an earthenware tile, slab, or plate. Sept. 14.—Mar. 14.

166. NEVIL SMART, Bridge Wharf, Hampstead-road, *Middx.*, Wharfinger; for certain improvements in preparing the materials for making bricks, which improvements are also applicable to other purposes. Sept. 21.—Mar. 21.

167. SAMUEL COWLING, Bowling, in the parish of Bradford, *York.*, Barber; for improvements in raising water, applicable to various purposes. Sept. 21.—Mar. 21.

168. WILLIAM JOSEPH CURTIS, Deptford, *Kent*, Engineer; for an improved boiler or apparatus for generating steam. Sept. 21.—Mar. 21.

METEOROLOGICAL JOURNAL FOR AUGUST, 1837; KEPT AT BLACKHEATH ROAD.

Day of Month	Barom. 9 A.M.	Ther. attch.	Barom. 3 P.M.	Ther. attch.	Thermometer.		Daily Temp.	Solar Var.	Rad.	Clouds.		Winds		Direction of Wind		Lunation.	WEATHER, &c.
					Min.	Max.				A.M.	P.M.	A.M.	P.M.	A.M.	P.M.		
Tues. 1	29·791	68°	29·735	69°	55°0	65°0	60°0	10°0	54	10	10	1	0	E	E	●	Rainy. *Sun not seen once this day.*
Wed. 2	29·735	69	29·710	70	58·5	72·5	65·5	14·0	58	10	9	3	2	swbs	SSW		Showery; wind very high. Afternoon moderate.
Thurs. 3	29·755	68	29·748	70	56·5	70·4	63·5	13·9	53	5	4	4	4·3	SSW	SW		High wind. *Cumuli.*
Friday, 4	29·904	69	29·982	70	53·9	70·0	61·9	16·1	51	6	6	2	2	WSW	W		Dense *Cumuli* into *Nimbi*, with showers.
Satur. 5	30·200	68	30·218	69	45·0	65·9	55·5	20·9	43	4	5	1	0	W	N		Hazy. *Cumuli.*
SUN. 6	30·281	67	30·289	68	47·4	66·0	56·7	18·6	45	5	6	2	2	NE	ENE		Cool. *Cumuli.*
Mon. 7	30·382	67	30·397	68	51·7	66·5	59·1	14·8	50	8	5	2·3	2	ENE	EbN		Much cloud till 4 P.M. Evening clear.
Tues. 8	30·404	67	30·360	68	48·0	66·6	57·3	18·6	46	5	3	3	3	EbN	ENE		Mostly clear; windy and dry. Scud at night.
Wed. 9	30·176	67	30·060	69	52·2	71·0	61·6	18·8	50	5	5	2	2	ENE	E	☽	Light *cumuli*; fine. Evening cloudy.
Thurs. 10	30·002	68	29·950	72	58·0	74·8	66·4	16·8	56	7	4	1	1	E	E		Cloudy morning. Fine. Faint *lightning* at night.
Friday, 11	29·915	72	29·950	73	61·4	79·0	70·2	17·6	59	7	2	0	2	SE	SSW		*Stratus* till noon. Fair.
Satur. 12	30·049	72	30·032	73	55·5	77·5	66·4	22·0	52	7	3	1	1	WSW	SW		*Cumuli*; fine.
SUN. 13	30·202	72	30·206	73	54·6	74·8	64·7	20·2	50	6	3	1	1	W	W		*Stratus* till 9. Day fine and cloudless.
Mon. 14	30·306	73	30.300	75	52·6	76·8	64·7	24.2	49	3	1	1	2	E	E		*Cumuli.* P.M. fine. Air cool at night.
Tues. 15	30·302	73	30·242	75	52·0	76·0	64·0	24·0	48	1	5	2	2	ENE	ENE		Windy. *Cumuli.* Air *dry* and *harsh.*
Wed. 16	30·150	72	30·058	73	58·2	73·2	65·7	15·0	54	3	8	2	1	NE	E	○	*Stratus* till 10. A shower at noon. Eve fine.
Thurs. 17	30·084	73	30·050	77	60·1	82·4	71·2	22·3	56	4	3	1	1	ESE	sly. w		Do., and hot. *Dense thunder clouds to* N.
Friday, 18	30·195	72	30·196	76	57·2	78·5	67·9	21·3	55	8	5	1	0	W	W		Do., *Cumuli.* Calm hot weather.
Satur. 19	30·150	73	30·056	76	57·0	81·0	69·0	24·0	55	5	7	1	1	S	E.SE		*Cirro-cumulus.* Sultry; lightning at night.
SUN. 20	29·956	75	29·992	75	65·5	76·5	71·0	11·0	62	5	3	3	3	swbw	swbw		A shower at 2 A.M. Clear; air cooler.
Mon. 21	30·142	73	30·120	75	57·4	76·0	66·7	18·6	54	5	10	2	3	SW	SW		Overcast. Windy wild weather.
Tues. 22	30·200	72	30·165	74	56·0	75·5	65·8	19·5	52	7	10	2	1	WSW	W		Heavy masses of *scud.* Heavy rain at sunset.
Wed. 23	30·101	72	30·084	74	63·5	73·9	68·7	10·4	62	10	10	1	2	SW	E	☾	*Cirro-stratus* and *scud.* Rainy Afternoon and Eve.
Thurs. 24	30·246	70	30·250	71	53·8	63·5	58·7	9·7	52	10	5	2	2	NE	ENE		Fine Night; sharp and cold.
Friday, 25	30·262	67	30·200	69	43·2	66·0	54·6	22·8	41	3	2	1	1	S	S		Very fine day. *Aurora* brilliant at night.
Satur. 26	29·924	67	29·901	71	48·9	73·5	61·2	24·6	46	7	10	2	2	SSW	WNW		Rain at sunrise. Heavy thunder-showers.
SUN. 27	30·204	66	30·224	67	45·4	57·8	51·6	12·4	42	1	4	2	1	N	N		Cool. *Cumuli.* *Aurora* at night.
Mon. 28	30·075	64	29·900	66	40·2	66·0	53·1	25·8	37	5	5	2	1	sbE	sbE		Very cold night; fine. Eve overcast.
Tues. 29	29·551	66	29·501	66	52·0	61·8	56·9	9·8	50	10	10	1	1	NE	N		Rain without intermission all day.
Wed. 30	29·450	64	29·525	64	54·9	60·8	56·4	8·9	50	10	7	2	1	NNW	W		Heavy rain, A.M. Thunder from 2 to 4. Clear eve.
Thurs. 31	29·488	63	29·449	65	44·8	62·2	53·5	17·4	41½	3	5	2	1	W	SW	●	Fine. *Cumuli.* Lightning in the evening.
Mean.	30·052	69	30·027	71	53·46	71·01	62·24	17·55									

Bar. Max. 30·404 in. on the 8th.
Bar. Min. 29·435 in. ,, 30th.

Ther. Max. 82·4° on the 17th.
Ther. Min. 40·2° ,, 28th.

Lowest point of Rad. 37°, on the 28th.
Rain fallen (by Crossley's self-registering gauge), 4·655 in.

THE HYDROMETER.

Introduction.

The young student in science is frequently led to suppose that the division of the natural laws into distinct sciences is the work of nature, instead of being merely the arbitrary distinctions, which the philosopher has introduced for the convenience of classification and arrangement. When we hear of the sciences of Pneumatics, of Hydrostatics, and of Acoustics, for example, it is natural to consider them as separate branches of inquiry, having no apparent connexion. But this view would be erroneous and inconsistent with that beautiful harmony, the result of adaptation the most perfect, which pervades all nature. Our knowledge is divided into separate portions, it is true, and to each portion it has been found convenient to attach a name; but the same laws which regulate pneumatics, apply also to hydrostatics; and acoustics could not exist as a science, if deprived of the aid of the other two. In short, it is for the convenience of study and of reference that we divide and subdivide the natural laws, and place in one division one set of phenomena, and another set of phenomena in another division. That nature does not recognise these distinctions, will appear obvious, from the fact, that not only is sound due to vibration, but that also light, heat, and electricity are, according to the most general and rational opinions, due to the same cause. On the subject of these conventional distinctions, Dr. Priestley, half a century ago, well observed:—"The objects of science are so multiplied, that it is high time to subdivide them. Thus the numerous branches of an overgrown family, in the patriarchal ages, found it necessary to separate; and the convenience of the whole, and the strength and increase of each branch, were promoted by the separation." If this were true in the time of Priestley, how much more so is it at the present day, when the amount of scientific knowledge, the inestimable result of the labours of so many inquirers in every part of the civilized world, has so largely increased. Since Priestley's day, geology has changed its aspect from a mass of crude theories to a body of highly valuable facts. Again, electro-magnetism, electro-chemistry, polarization of light, have all sprung up into sciences since the age of Priestley; and as they sprung up, so was it necessary to find a distinctive place for them in the catalogue of human knowledge. If, therefore, for the correct appreciation of scientific principles, it be desirable to consider all the sciences as so many tints of one splendid colour, it is eqally desirable for practical study, that we should give to each tint a distinctive name proper to itself.

In commencing a description of another of those ingenious contrivances, by whose means man is assisted in his application of the unerring laws of nature, it will not excite surprise that the same general principles which regulate the action of the barometer apply also to the hydrometer*:—one measures the weight and pressure of the air; the other measures the density of liquid bodies; and, as we began our former article with a description of the atmosphere whose pressure was to be measured, so shall we now, as far as applies to our subject, examine the properties of the waters, and of liquids generally, whose densities are to be measured, of the relation between liquids and solids with respect to their comparative weights; and the second part of our subject will be devoted to a description of those contrivances by which the density of liquids is ascertained, together with their application in science and the useful arts.

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* From *ὕδωρ*, water, and *μετρεω*, to measure.

SECTION I.—THE WATERS.

WATER, one of the most abundant and powerful agents of nature, was one of the very few elements of ancient philosophy:—indeed, the names of Becher and Stahl remind us that even past the middle of the last century, water was one among the bodies enumerated as simple elements; Becher having advocated three such elementary bodies, air, water, and earth; and Stahl having appended to them a fourth, viz., phlogiston, or the principle of fire. Modern science, however, has proved the compound nature of water, and has demonstrated, by beautiful and convincing experiments, that it is composed of two volumes of hydrogen gas and one of oxygen gas. Hydrogen is sixteen times lighter than its own bulk of oxygen; in fact, it is the lightest body in nature which the most delicately-constructed balance has ever weighed.

All those bodies are termed fluid which are supposed to result from a collection of material particles, whose size is infinitely small, and which move freely on each other in every direction, without the retarding agency of friction: in this sense, water, oil, mercury, steam, vapour, and air, are all fluids. Another distinctive property of fluids is, that when confined by pressure, they also exert a pressure which is equal in all directions. These properties are general, and apply to all fluids; but most important distinctions are observable in the two sub-sections into which they may be divided. If we have a cubic foot of air, and by some mechanism are enabled to enlarge the capacity of the containing vessel to two cubic feet, the air will instantly fill the whole of the enlarged capacity; but if the cubical vessel contain water in the first instance, the enlargement of the vessel will not cause an enlargement in the bulk of the water; the latter will remain the same in bulk as before. This distinction is conveniently denoted by the terms *elastic* and *non-elastic* fluids; the former being applied to those which would fill a containing vessel, however much its capacity may be increased, and the latter to those which suffer no change of bulk from that circumstance. These non-elastic fluids, such as water, oil, spirits, mercury, &c., are in common language known as *liquids*, and the elastic fluids as *airs*: the term *non-elastic*, however, requires a reservation, of which we shall treat presently. Elastic fluids are further divided into two species, in order to indicate the peculiarities which distinguish *vapours* from airs: the term vapour being applied to those airs whose liquid origin is familiar to us *at ordinary* temperatures: thus, if water be reduced in temperature, it becomes solid; if its temperature be elevated, it is vaporized, or converted into a vapour which is visible; if it be heated still more out of contact from the cool air, it becomes *steam*, which is invisible, and that steam possesses the fluid property of *expansibility;* but upon a reduction of temperature, it regains the liquid form. Now, as a similar phenomenon never occurs with common air, it is convenient to adopt the distinctive term of vapour for the former fluid.

Another distinction between the different kinds of fluids has been often instituted. Those which have the property of adhering* to other bodies have been called liquids, such as water, oil, &c., while those which do not possess this property have been considered as fluids, such as air, melted metals, mercury, &c. Now, that this distinction will not hold, the arts furnish us with a striking proof. When the surface of a metal is covered with gold, it is said to be watered, while a similar metal, covered with silver, is said to be plated. Now the two dissimilar metals adhere by a force which is called affinity; and although mercury will not stick to the hand, like water, if plunged into a cup of it, yet there are many metals to which it will adhere. Gold has an affinity for many metallic bodies; or, to speak technically, it *waters* these bodies; mercury also waters gold, silver, tin, lead, &c.; and the force of attraction between mercury and other metals has been calculated in the following manner. When a smooth plate of any substance is brought in contact with a liquid, a greater force is necessary to raise it than when it is not so in contact. This excess of force is the force o adhesion, and is the same in each body, provided the surface remains the same. Different metallic disks of the same size adhere to mercury with forces represented by the following figures:—

Gold	23·63	Platinum . . .	14·98
Silver . . .	22·74	Zinc . . .	10·81
Tin	22·15	Copper . . .	7·52
Lead . . .	21·04	Iron . . .	6·10
Bismuth . . .	19·71		

But all the distinctions between fluids and liquids are uncertain, and cannot be insisted on, since many of the gases which were once called *permanently elastic*, i. e., incapable of being reduced to a liquid or solid form, have, through the united agency of pressure and low temperatures, been reduced to the liquid form; and analogy would lead us to suppose that all the gases, and even atmospheric air, are capable of being reduced to the liquid, or even to the solid form, if we could only command sufficient pressure, and procure a temperature sufficiently low. The necessity for a low temperature will be seen, when we remind the reader that heat produces expansion in all bodies, and upon heat alone does the very existence of several forms of matter depend.

In our paper on the Barometer we pointed out the chief properties of the atmospheric air, under the terms impenetrability, inertia, mobility, and weight; we need not now consider the same properties with reference to water, as their application is nearly the same: we proceed, therefore, to notice other phenomena which belong more exclusively to liquids.

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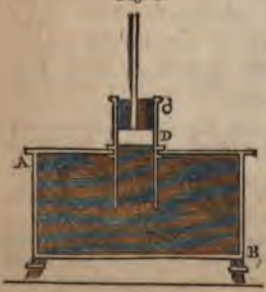
* The term *cohesion* is frequently introduced in opposition to *adhesion:* the former implies that force by which the particles of a substance are held together; the latter applies to that force by which it clings to other bodies.

The first and most striking property of liquids is the tendency they all have to adjust themselves to a horizontal level; this is due to their mobility, or the facility with which they move, and the tendency of all their particles to fall as low as possible. Its operation may be seen on a grand scale in nature,—in the motion of mighty rivers as well as that of the most insignificant brook: in the fall of the stupendous cataract, or the minutest waterfall:—all are hastening on, guided and directed by the all-pervading force of gravity, in search of the lowest level; forming in their course the mountain torrent, the expansive lake, the river, the brook; and producing that exuberant wealth to the vegetable world, and healthful freshness to the animal world, which cannot be sufficiently appreciated, until we form a contrast of all this with the arid deserts of Arabia, where a cup of cold water is above all price, and which is often not to be purchased by gold.

In consequence of the perfect mobility of water, the liquid level is the only perfect level with which we are acquainted in nature or in art. A still lake, unruffled by the slightest breath of air, is one of the finest examples of a perfect level that we possess. Formed by the attraction of gravitation, it follows, then, that this level is not, as we are accustomed in common language to call it, horizontal, but partakes of the earth's curvature; every portion of the lake's surface is therefore equi-distant from the centre of the earth (excepting that slight deviation due to the spheroidal figure of the earth,) but so small a proportion does a sheet of still water bear to the diameter of the earth, that the curvature of the former is not at all perceived; and for all ordinary practical purposes fluid surfaces of small extent may be considered as plane. If a line be tightly drawn across a circular lake of the diameter of two miles, and crossing the centre be fastened at two opposite points of the circumference; if the ends of the line just touch the surface of the water, the line would dip under the water four inches only in the centre,—that is, the centre of the lake would be four inches higher than the edges, considered with reference to a straight line; a degree of elevation which, in practice, is almost inappreciable. Hence we learn that a perfect level on the earth's surface is never a right line or a plane surface, but a portion of a curve of 4000 miles radius.

Fig. 1.



A second important property of liquids is that of transmitting pressure in all directions. From our definition of a liquid, it follows that any disturbing force causes it to yield to that force, whether it be the gentlest breeze, or the mighty forces which produce the spring-tides: but, in these cases, a liquid is set in motion by a force, because the liquid is free to move, and if subjected to force, can only be at rest when forced in all directions. If a liquid such as water be confined in a closed vessel such as A B, entirely filled, having an aperture at D, in which is inserted a cylinder C, descending into the liquid,—if this vessel were filled with air instead of water, the piston contained within the cylinder might be forced down, and the resistance of the air to compression would not be very great, but water would so effectually resist compression, that the vessel A B would be burst out before the water yielded to the force exerted on the piston. This is, in fact, what would ensue, supposing so small a force as one pound were exerted on the piston, the contents of whose base we will suppose to equal one square inch.

Now, the force exerted on the inner surfaces of the vessel is easily calculated, supposing the surfaces to be plane; we have only to multiply the length of each surface (in inches) by its breadth, which will give its area; then by adding the area of all the surfaces, we shall get the whole interior or exterior surface of the vessel. Thus, suppose the total area of the inner surfaces of the vessel amounted to 8000 square inches, each square inch would have to bear the pressure of one pound exerted by the piston; the total force, therefore, tending to burst the vessel would amount to the enormous sum of 7999 pounds, a force which few vessels would be able successfully to resist.

Now, the reason of all this is to be found in two properties of liquids which are here simultaneously in operation. The first is the perfect mobility of water, by which it so readily yields to any impulse when it is not confined; and the second, that remarkable property which may be called its incompressibility, since it is sufficiently correct for all practical purposes to consider liquids to be incapable of occupying a smaller space by pressure than they already occupy in their free state. Still, however, the accurate rigour of modern science will not allow us thus to pass by a property which seems common to all matter; and although the compressibility of liquids is small, yet the very circumstance of their being compressible at all, is sufficient grounds for us to notice this property. By a series of five experiments, M. Œrsted has discovered that a pressure equal to a column of water 32 feet high produces in pure water a diminution of 0·000045. Canton had previously found that, under the same pressure, the following liquids underwent the following diminutions:—

Sea water	0.000040
Rain water	0·000046
Olive oil	0·000048
Spirit of wine	0·000066
Mercury	0·000003

These diminutions are nearly in the inverse ratio of the densities of the liquids. Mr. Perkins, in a series of experiments with a pressure 1120 times greater than that employed by M. Œrsted, is said to have produced a diminution of 0·06. We shall return to this subject when we come to speak of the density of liquids.

Since a liquid, then, confined in a close vessel, cannot be much compressed by an ordinary force, and as all the particles of a liquid are so connected as to press equally in all directions, and as each particle is pressed by the adjacent particles whether they be above, below, or on any side; and as all the particles in their turn press upon all the sides of the vessel which contains them with a force of their own, depending upon the height of the fluid multiplied by the extent of surface upon which it rests, it follows that any force communicated to the liquid is equally dispersed through and transmitted by the watery particles; and hence it is that the surface of the containing vessel receives so enormous a pressure from a force apparently insignificant.

But although the most gigantic mechanic power which man can command fails to compress water to any extent, yet nature reduces its bulk with unerring precision by means, certain though silent in their action, and, like all her operations, beautifully simple. The mere abstraction of heat is sufficient to effect this, and we find, accordingly, that all bodies contract in bulk by cold (cold being, in fact, nothing more than diminished heat, and not a principle in itself,) and expand by the application of heat*. Now, it is very important to our present purpose to ascertain the chief points which regulate the change of bulk in liquids by change of temperature; and water being the most important, as it is the most abundant of the liquids, we shall chiefly confine our observations to it,—first, premising that the general laws which regulate the contraction of water, apply, for the most part, but not altogether, to other liquids.

The reader will have a clear view of the nature of expansion by considering that "matter of every kind is nothing more than an assemblage of material particles held in equilibrio by the force of cohesion, which tends to unite them, and by a repulsive force which is probably caloric, or the principle of heat, which tends to separate them."—(*Biot.*) That in proportion to the presence of this principle of heat we get the various states of matter,—solids, liquids, and airs;—in short, one may be resolved into the other by the application or abstraction of heat. Of the three states of matter, airs alone expand equally for equal increments of heat, the rate being $\frac{1}{480}$th part of their whole bulk for every degree of Fahrenheit's thermometer; but no such law regulates the expansion of solids and liquids, since it appears that every solid and liquid has an expansibility peculiarly its own. It is important, therefore, in treating of liquids, to ascertain the amount of expansion of each under a given increase of temperature, and this has been done with much precision by various philosophers. The following table shows the expansion of a few liquids from 32° to 212°, the bulk at 32° being considered as unity:—

			Equal to an increase in the whole bulk of
Alcohol	0·11000	=	$\frac{1}{9}$
Fixed oils	0·08000	=	$\frac{1}{12}$
Sulphuric ether	0·07000	=	$\frac{1}{14}$
Oil of turpentine	0·07000	=	$\frac{1}{14}$
Brine, or water saturated with salt	0·05000	=	$\frac{1}{20}$
Water	0·04444	=	$\frac{1}{22{\cdot}5}$
Mercury	0·018018	=	$\frac{1}{55{\cdot}5}$

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* Water is not so susceptible of compression in high temperatures as in such as are lower. The very act of compres*sion, too, occasions* a rise in temperature. *M. Œrsted found* that one degree of Centigrade caused, at high temperatures, the volume of the water to vary more than the pressure of three, four, or even five atmospheres.

Water, it will be seen, by gaining an accession of heat equal to 180°, gains an increase in bulk equal to rather more than one part in twenty-two, or, to speak more familiarly, 22 pints of water at 32°, become 23 pints at 212°.

From what has been said, it would be naturally inferred that, as by the addition of heat, liquids expand* in bulk, so by a diminution of heat their relative and respective bulks would be diminished; but it is a most remarkable fact, important not only in science, but also in the arts, that water and a few other liquids† contract by cold only within a certain limit, beyond which if cold be continually applied, all contraction ceases; nay, on the contrary, expansion re-commences just as if heat were applied.

This very curious and instructive phenomenon was first noticed in water by the Florentine academicians about the year 1670. They filled a glass ball, which had a long and narrow neck, with water, and plunged it into a mixture of salt and snow, which produced the most intense cold known at that time; the water suddenly started up in the neck, in consequence, as it would appear, of the contraction of the glass vessel by cold, but the water also soon contracted as it parted with heat, and its contraction continued down to a certain point, when it began to retrace its steps: it expanded and ascended slowly in the tube until a portion of the water in the bulb became solid ice, and then the water in the stem shot up suddenly with considerable velocity. Modern science has determined, with its accustomed accuracy, the temperature when water ceases to contract by cold, and when expansion begins, from the same cause, at 39·38° Fahr.; and this is called the state of greatest condensation of water, which, as we stated in our paper on the Vernier, has been adopted by the French as the basis of their system of weights and measures. It will be remembered, then, that at about 40° water is in its state of greatest condensation,—that is, it is reduced to the smallest possible dimensions of which it is susceptible by cold alone, and that its particles are as closely connected together as is possible. The physical reason why expansion takes place after this seems to be a re-arrangement of particles by which the crystalline form of the solid which is about to be produced occupies more space than the particles in the liquid form.

The apparent exceptions to a natural law, however perplexing they may, at first view, appear to the student in science, become, when viewed by the instructed confidant of nature, so many beautiful extensions of the same law: or rather, when the operation of one law ceases, the governing power is taken up by another, and carried on as if it were part and parcel of the original law: thus, steam is subject to the general and equable law of expansibility which regulates all airs; but when by a reduction of temperature steam is condensed into water, the laws of liquid expansion apply, and when it becomes solid ice, a third general law regulates its varying bulk. Now supposing that water regularly contracted from its liquid to its solid state, it is quite clear that a certain bulk of ice would occupy less space than the bulk of water which formed it; its weight would be, in short, bulk for bulk, greater than that of water, and it would consequently sink, and our streams in winter, instead of the superficial crust of ice which covers them, and which is easily thawed, would become one solid mass of ice, destroying all that life with which the waters teem, and would occupy a whole summer to become again liquid, since water is so imperfect a conductor of heat.

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* Enlargement in bulk by the application of heat is sometimes termed *dilatation*, and sometimes *expansion*. The former term, however, implies an enlargement laterally in one direction only, and therefore is not so appropriate as the term expansion.

† Among other bodies which experience an increase of volume *in passing* from the solid to the liquid state, we may mention iron, bismuth, bronze, antimony, &c. Antimony is put into the lead with which printers' type is formed, because the expansion of the melted metal, on cooling, fills up the mould, and gives that sharp, full appearance to the letters, which could not be insured by lead alone, which contracts, on cooling, instead of expanding.

We have spoken of the point of greatest condensation of water as a fixed point; as a natural standard which is presumed to be invariable: now the freezing point of water all over the world is 32° Fahrenheit; but, as our readers know, its boiling point is variable, depending upon atmospheric pressure: it follows then, that pure water at a fixed temperature occupies the same bulk all over the globe; that a pint of pure water at 60° is absolutely a pint, and neither more nor less at any time or place where it may happen to be.

When we speak of pure water we do not mean that of the "limpid brook," "the majestic river," or "the deep, deep, sea;" for, however pure the waters of these sources may be in poetry, they are absolutely impure for scientific purposes. The waters of the brook, and of the river, flowing over mineral beds, dissolve and hold in solution various substances depending upon the nature of the bed: in some waters are found chalk, magnesia, oxide of iron and other bodies, which render its weight variable; and sea water contains much salt and other matters, all which prevent their being taken as a standard of universal reference. Now, pure water may be obtained by distillation, that is, by raising the temperature of the water to the boiling point, when its vapour will pass off and leave all the other matters, which are considered as impurities, behind; if the vapour be received into a cool vessel it will be condensed and yield water absolutely pure,—that is, it will furnish by analysis oxygen and hydrogen, and nothing more.

We have purposely delayed until now the consideration of another property of water, viz., its density, because it is so intimately connected with that which is immediately to follow.

In consequence of the attraction of cohesion operating less perfectly in liquids than in solids, gravity acts with full force upon the former, producing a horizontal level, the result of equal attractions towards the centre of the earth; but, in solids, if a single point, the centre of gravity, be supported, the whole mass will be in equilibrium. All the particles of a liquid then are tending to the lowest point, and consequently the base of a liquid column is, in addition to its own gravity, subject to that of the whole liquid mass above it; hence, if a hole be opened in the bottom of a vessel full of water, the liquid will rush out with a force proportioned to its distance from the top of the vessel. Thus, if a cylindrical vessel, six feet in height, had an orifice in the bottom of such a size as to suffer all the water to flow out in half an hour, and if this vessel were filled with water, the water would begin to flow out with a rapidity of 11½ inches in the first 2½ minutes, but after it had been flowing 27½ minutes out of the 30, 71½ inches out of the 72 would have flowed out, leaving only half an inch of water to flow in 2½ minutes; in other words, the rapidity of the flow is twenty-three times as great when the vessel is filled to the top, as when it is filled to half an inch*. This results from the law, that the quantity which flows out in a given time increases, not simply as the height, but as the square of the height. The same law regulates the flow from any other aperture in the side of the vessel. If an open tube be inserted vertically in the vessel, the liquid will immediately ascend the tube, until its level correspond with that in the larger vessel; this shows the downward, lateral, and upward pressure of liquids; but suppose the liquid column be continued downwards to an indefinite extent, it follows that the lowest stratum of water, having to bear the weight of that above it, will be compressed, (for we have seen that water is compressible,) the compression of course depending upon its own superincumbent weight. Professor Leslie has observed, that if air be compressed into the fiftieth part of its column its elasticity becomes augmented fifty times; that if it continues to contract at that rate, it would, from its own incumbent weight, acquire, at the depth of thirty-four miles, the density of water; that water itself, at the depth of ninety-three miles, would have its density doubled, and would even acquire the density of mercury at a depth of three hundred and sixty-two miles. At the centre of the earth, Dr. Young says, that steel would be compressed into a fourth, and stone into one eighth, of their bulks.

Let not the reader smile at these statements, and feel disposed to place them in the romance of science, since the names of the profound and admirable philosophers, under whose sanction they are here given, are quite sufficient to repress the vulgar clamour of ignorant incredulity, when it is known what are the data upon which these conclusions are founded. Great names should not certainly command implicit belief, but they should command respect, for although philosophers are not yet acquainted with the laws of compression of solid bodies beyond a certain

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* Should the reader experience any difficulty in accounting for the great disparity between the quantity of water which escapes during the first and the last two and a half minutes of the half-hour, he is reminded that the velocity of the flow decreases in the same ratio as the velocity of a falling body increases:—thus, if a stone fall from a height towards the earth, during the first unit of time (and this may be one second, one minute, or two and a half minutes, or any number agreed on), through a space represented by one, it will fall through three times that space during the 2nd second; through five times that space during the 3rd second, and so on; the spaces fallen through being in proportion to the squares of the times: thus $1 + 3 = 4$ which is the square of two seconds; $1 + 3 + 5 = 9$ or 3^2; $1 + 3 + 5 + 7 = 4^2$, and so on. The following table will render the statement made in the text still more simple—

23 half-inches flow during	the first	2½ minutes.
21 . .	second	2½ minutes.
19 . .	third	2½ minutes.
17 . .	fourth	2½ minutes.
15 . . .	fifth	2½ minutes.
13 . .	sixth	2½ minutes.
11 . .	seventh	2½ minutes.
9 . .	eighth	2½ minutes.
7 . . .	ninth	2½ minutes.
5 . .	tenth	2½ minutes.
3 . .	eleventh	2½ minutes.
1 half-inch flows during the .	twelfth	2½ minutes.
144 half-inches or 6 feet.		30 minutes.

limit, yet, that the above calculations are not overstated appears certain, if we may rely upon some experiments of Mr. Perkins, on the compressibility of water. He constructed an apparatus which consisted chiefly of a stout cylinder of brass, containing water, and a rod moving in the top through an air-tight and water-tight hole; the top of this rod was furnished with a spring ring, which remained fixed at any point at which it was placed, and, therefore, served as an index of compressibility. Having plunged his apparatus into the sea, five hundred fathoms deep, the ring was found to stand eight inches high on the rod. From this he inferred that the rod had, at the greatest pressure, been forced eight inches into the cylinder, and as the spring could not enter the latter with the piston, it was consequently thrust up the handle, where it remained fixed. Mr. Perkins calculated that the water had been compressed $\frac{1}{21}$th part of its bulk.

By density, then, we mean the quantity of matter enclosed within a certain space, and the more matter that this space contains the denser is the body which is enclosed by such space, and *vice versâ*. Two bodies, then, which enclose the same quantity of matter in the same space are equally dense, the temperature of both being the same:—thus, a cubic inch of gold will weigh precisely the same as another cubic inch of gold, of the same purity, because both are of the same density; but a cubic inch of standard gold, that is, gold containing $\frac{1}{12}$th silver, would differ in density from a cubic inch of pure gold:—but density and weight are very distinct properties, for it is clear that a mass of cork may weigh exactly the same as a mass of lead, but the masses would not correspond in bulk, and this is quite sufficient to lead to the conclusion that the cork is not so dense a body as lead, although, in this case, the weights of the two bodies may be the same.

We say, familiarly, that cork floats in water, and that lead sinks; but from what has been shown of density, it by no means follows that a certain density of water may not be found in which lead would float; the only condition necessary is, that the lead and the water be of the same density, and if it were within the bounds of probability that the sea is in some places so deep, that, as the sounder declares, there is "*no bottom*," lead at a certain depth would float with as much facility in water as it does in mercury. Indeed, the depth at which lead floats in water is a matter of easy calculation, and it is by means of a given weight of this metal that an object is sunk to a given depth. Thus, Mr. Perkins employed fifty-four pounds of lead, in order to insure a depth of five hundred fathoms for this apparatus for ascertaining the compressibility of water, and this depth gave a pressure equal to one hundred atmospheres.

We have now arrived at the last part of the present section, wherein we propose to consider what apparent change a solid undergoes by immersion in a liquid.

It is a consequence of the impenetrability of liquids that every solid, when plunged into it, displaces a quantity exactly equal to its own bulk. It is also a consequence of the pressure of the particles of a liquid upon each other that a lighter body floats upon its surface; a body of equal weight remains at rest at the place where, having been immersed, it is allowed to remain, and a heavier body sinks in it; but its descent is retarded by the resistance of the liquid operating against the gravitating force of the solid. By measuring the exact quantity of liquid displaced by a solid, we ascertain with great precision the bulk of the latter, and it matters not whether the solid be very heavy or very light, a certain bulk will displace a certain quantity of liquid and no more.

If a body be weighed in air, and afterwards weighed in a liquid, it will appear in the latter process to have lost a part of its weight, and this loss, it will be found, is exactly equal to the weight of the quantity of the liquid displaced by the solid: therefore, by dividing the weight of the body in air, by the difference between that weight and its weight in the liquid, we ascertain how many times the weight of a certain bulk of liquid displaced is contained in the weight of the same bulk of the substance we are weighing: or, in other words, we ascertain its *specific gravity*.

The reason of this process will be, perhaps, better seen by putting it into the form of a proportion, thus:

As the loss of weight, when weighed in water
: Is to the weight of the body in air,
:: So is the weight of a given bulk of water
: To the weight of an equal bulk of the solid;
(or, so is 1, to the specific gravity of the solid).

Now it is of the first consequence that the term specific gravity should be understood in the same manner all over the world, so that philosophers in one country may repeat and verify the experiments of those in another country; it is necessary, therefore, to adopt some universal standard of comparison, and for this purpose pure water, at a certain temperature, is the most eligible; the best temperature would probably be the point of greatest condensation. But as this temperature would in summer, and in warm countries particularly, be inconvenient to procure, the temperature of 60° is generally adopted; not that a fixed temperature is absolutely necessary; the specific gravity of any substance may be taken, at whatever temperature water may be found to be, since tables are constructed which express the change of weight which a given bulk of water sustains with every change of temperature, so that a simple arithmetical process is sufficient to reduce the specific gravity of any substance to what it would have been at any other proposed temperature.

The adoption of water, as a standard of comparison, took its rise from a circumstance as little likely to lead to scientific results as the fall of the apple, which our immortal Newton is said to have witnessed in his orchard. But let us not suppose that so trivial a circumstance as this suggested the sublime theory of gravitation to the mind of our noble countryman; it is not by sudden and "happy" thoughts, as they are termed, that we gain admission into the secret workings of the universe. Nature selects her favourites, not with the blind partiality of fortune, from the dissolute and the idle, as well as from those whose mental stores are great and well applied, but her choice is from those alone who have undergone the rigorous and wholesome mental discipline which constitutes the very language in which she communicates her precious knowledge: what the world calls an accidental discovery in science, is a sad misapplication of terms:—any man may accidentally discover a large sum of hidden coin, but no man ever made the accidental discovery of a hidden principle of nature, which had defied all the powers of the good and the wise of past ages:—his mind must be prepared, by cultivation, for the reception of the hidden truth, in the same way as the good ground spoken of in the parable, which "received seed and brought forth, some an hundred-fold, some sixty-fold, some thirty-fold;" but how often it is that the seeds fall into "stony places," where, because "they take no root, they wither away." But to return.

Hiero, king of Syracuse, had given a workman a quantity of gold with which he was to construct a crown. When the crown was made and sent to the king, a suspicion arose in the royal mind that the gold had been adulterated by the alloy of a baser metal, and he applied to Archimedes, a celebrated philosopher, (who lived from 287 to 212 B.C.) for his assistance in detecting the imposture. As, at that time there were no known means of testing the purity of metal, this philosopher, after many unsuccessful attempts, was about to abandon the object altogether, in despair of being able to accomplish it, when the following trivial circumstance, to which we have just alluded, suggested to his discerning and *prepared* mind a train of thought, which ended in the accomplishment of the proposed object. Stepping into his bath one day, as was his custom, his mind, doubtless, fixed on the object of his research, he chanced to observe that the water rose in proportion as he plunged his body into the liquid, and that the proportion bore a relation to the bulk of his body. He probably perceived that any other body of the same bulk would have raised the water equally, but that another body of the same weight, but less bulky, would not have produced so great an effect. At this moment he must have experienced that intense pleasure which can only be appreciated by those who have felt the truth of a principle, sought for by long and patient labour, rush suddenly into the mind, and the joyous effect upon Archimedes is said to have been such as to cause him to leap from the bath, and to run into the street, exclaiming *Ευρηκα*! *Ευρηκα*! "I have found it out! I have found it out!" When his emotion had sobered down, he proceeded to investigate the subject calmly; he procured two masses of metal, of equal weight with the crown, one of gold and the other of silver; and having filled a vessel very accurately with water, he plunged into it the silver, and marked the exact quantity of water that overflowed. He then treated the gold in the same manner, and observed that a less quantity of water overflowed than before. He then plunged the crown into the same vessel, full of water, and observed that it displaced more of the fluid than the gold had done, and less than the silver, by which he inferred that the crown was neither pure gold nor pure silver, but a mixture of both.

The problem which Archimedes had to solve would be to us, of course, easy, when the specific gravities of gold, of silver, and of the crown, are known. If the specific gravity of gold be taken at 19 (that is, any mass of gold would be 19 times heavier than the same mass of water), silver 10, and king Hiero's crown 15; then the difference of the *specific gravities* are 9, 5, and 4; the products of each specific gravity, by the difference of the other two, are 135, 95, and 40: therefore, as 135 : 15 :: 95 : 10·555; and again, as 135 : 15 :: 40 : 4·444, whence the proportion of the gold to the silver in the crown, is as 10·556 to 4·444.

We have given the rule for ascertaining the specific gravity of a substance heavier than water: if a substance be, bulk for bulk, lighter than water, some heavier body must be attached to it whose specific gravity is previously known; the bodies thus attached are weighed together in air and in water, and the difference found. From this difference is subtracted the difference between the weight of the heavier body in air and water, and by this means the weight lost by the lighter body in water is ascertained,—by which its weight in air must be divided, in order to find its specific gravity, or expressed proportionally, thus:—ascertain what loss of weight the heavy body undergoes, on immersion in water, and then what loss the compound body undergoes:—then

As the difference between the losses
: Is to the weight of the light body in air,
:: So is 1
: To the specific gravity of the light body.

If the body to be weighed, although heavier than water, be in the form of filings or grains, the following mode must be adopted. Put the filings into a small bucket, or cup, having previously weighed the empty bucket in air; then the difference between the weight of the full bucket and the empty bucket is the weight of the filings in air. Perform exactly the same process in water, and we get the weight of the filings in water: then—

As the difference of those weights
: Is to the weight of the filings in air,
:: So is 1
: To the specific gravity of the filings.

The specific gravity of a fluid is easily found by employing a bottle which is counterpoised in the scale, and which contains exactly 1000 grains of distilled water at 60°: it evidently follows that if the bottle be filled with a fluid denser or lighter than water, the equipoise will be in both cases disturbed, and the number of grains added to either scale will show the specific gravity of the fluids.

We will now give examples of the mode of taking the specific gravities of three substances:—first, a heavy solid; secondly, a light solid; and thirdly, a liquid. 1. In order to ascertain the specific gravity of a piece of stone, which in air, weighs 600 grains, and in water only 400, we know that a quantity of water, equal in bulk to the stone, would weigh 200; now, the weight of the stone in air is 600, which, divided by its weight in water, gives 200; the stone is therefore three times heavier than the water. If we call the specific gravity of water 1, that of the stone will be 3; if we call the specific gravity of water 1000, that of the stone will be 3000, for it evidently matters not whether the unit of comparison be 1 or 1000; the result is the same, since the object of obtaining the specific gravity of a body is not to ascertain its actual weight, but its density, or the number of times the same bulk of a known standard is contained within itself. In practice, however, it is found convenient to employ 1000 as the numerical denomination of the standard: as it happens rather remarkably that a cubic foot of water weighs, within a small fraction, 1000 ounces. When, therefore, we see that the specific gravity of any body, a metal, for instance, is put at 7·525, we know that a cubic foot of it weighs 7,525 ounces, or 470 pounds 5 ounces avoirdupois, which gives 4·355 ounces as the weight of a cubic inch of the metal.

2. To find the specific gravity of a piece of light wood, which, in air, weighs 5 ounces, we attach to it a smooth stone, which in air, weighs 12 ounces, and in water 6, making a difference of 6 ounces. The stone and the wood, when attached, weigh 17 ounces in air, and only one ounce in water, making a difference of 16 ounces. From this difference we deduct the difference formerly found between the weight of the heavier body in air and in water, and thus obtain the difference 10, between the weight of the lighter body in air and water. By this difference 10, we divide the weight of the lightest body in air, 5, and thus find the specific gravity to be $\frac{1}{2}$, if water be accounted 1, or 500, if the specific gravity of water be 1000.

3. The bottle being filled with a liquid, say alcohol, and put in one scale-pan, and a weight which exactly counterpoises the empty bottle in the other scale-pan, together with 1000 grains weight, equal to 1000 grains of water at 60°, it is evident that these two weights would counterpoise the bottle if filled with water at 60°, but if filled with a fluid lighter than water, the two weights would be too heavy for the bottle and its contents; we, therefore, add weights to the pan containing the bottle, until one pan equipoises the other. Suppose these weights amounted to 198 grains: this deducted from 1000 grains would give 0·802, the specific gravity of the alcohol. If the liquid were heavier than water, it would be necessary to add weights to the 1000 grains; the bottle being filled with strong sulphuric acid, for example, it would be found necessary to add 700 or 800 grains to the 1000, and this would indicate a specific gravity of 1·700 or 1·800, as the case may be.

We will conclude this section with a notice of the specific gravities of a few well-known substances.

WOODS.		LIQUIDS.	
Cork	0·240	Sulphuric ether	0·715
Poplar	0·383	Absolute alcohol	0·792
Apple	0·793	Spirit of wine	0·837
Beech	0·852	Distilled water	1·000
Oak	0·925	Sea water	1·026
Mahogany	1·063	Milk	1·030
Pomegranate	1·354	Mercury	13·586

METALS.	
Potassium	0·865
Iron	7·207
Silver	10·474
Lead	11·352
Gold	19·362
Platinum	22·069

The specific gravities of gases are compared to that of pure and dry atmospheric air stated as 1 to 1000. Thus the density of chlorine is 2·5 or 2500,—that is to say, it is twice and a half heavier than air.

A POPULAR COURSE OF GEOLOGY.

XII.

SIMPLE MINERALS ENTERING INTO THE COMPOSITION OF ROCKS.

IN treating of the different formations of geology, we shall take them in the ascending order, beginning with the unstratified rocks, granite, one of the principal of these, being the lowest rock met with, and the most generally diffused. We shall then proceed to the stratified rocks, commencing with the most ancient. Since the classification of the unstratified rocks depends on their mineral character, it will be necessary first to make the student acquainted with those simple minerals of which they are composed.

The following list comprehends all that are absolutely necessary to be known by the young geologist. Those which are of most common occurrence, and enter most largely into the composition of rocks, are placed at the head of the list. The last three generally occur sparingly, disseminated through certain rocks, and are only occasionally present in sufficient quantity to be considered as essential ingredients:—

Quartz,
Felspar,
Compact Felspar,
Clinkstone,
Claystone,
Mica,
Talc,
Chlorite,
Hornblende,
Augite,
Actinolite,
Hypersthene,
Diallage,
Steatite,
Serpentine,
Carbonate of Lime,
Carbonate of Magnesia,
Bitterspar,
Dolomite,
Sulphate of Lime
Bitumen,
Oxide of Iron,
Sulphuret of Iron,
Schorl,
Chiastolite,
Garnet.

QUARTZ.

THIS mineral is nearly pure silicic acid. It occurs under the following forms:—Compact, in veins and quartz rock;—as nodules, in amygdaloidal rocks;—as rolled masses, in conglomerates;—as rounded grains, in sandstones, some kinds of quartz rock, and coarse clay slate;—crystallized in the substance of granite, porphyritic, and other unstratified rocks. The commonest forms of the crystals are six-sided paramids, and six-sided prisms, terminated by six-sided paramids.

Quartz crystals may be cleaved, though with great difficulty, parallel with all the faces of the common crystal, producing a rhomboid, which is the primitive form.

The following are the external characters:—*Fracture*, commonly conchoidal:——*Lustre*, vitreous, inclining in some varieties to resinous:——*Transparency*, of various degrees, from quite transparent to translucent or opaque:——*Hardness:* scratches glass, does not yield to the knife; when compact enough, gives sparks with steel:——*Powder*, white:—— *Phosphorescence:* some varieties yield a phosphorescent light, and an empyreumatic odour when rubbed:——*Specific Gravity*, 2·6 to 2·7:——*Before the blowpipe*, infusible alone.

Crystals of quartz often enclose foreign bodies, such as water, air, chlorite, bitumen, crystals of titanite, &c. They also acquire various shades of colour from minutely-divided foreign matter, intimately blended in their composition. The following are the names by which some of the varieties of coloured quartz are known.

ROCK CRYSTAL.—This name is given to the most perfectly transparent crystallized specimens, and to some transparent or semitransparent massive varieties. The finest specimens are from the Alps of Salzburg, the Tyrol, Switzerland, Dauphiny, Piedmont, Madagascar, Ceylon, and Brazil.

MILK QUARTZ.—Opaque quartz, both massive and crystallized, nearly of the colour of milk. The crystals of this, and of all coloured varieties of quartz, are more regular in their forms than those of transparent quartz.

ROSE QUARTZ.—A variety of milk quartz, both crystallized and massive, translucent, and of a rose red, supposed to derive its colour from manganese. The finest and most transparent varieties, which are cut and polished, and are known among jewellers as *Bohemian rubies*, are from Bohemia, Bavaria, and Siberia. The varieties approaching milk quartz are from Norway, France, and Spain.

AMETHYST.—Colour, various shades of violet and purple, the colouring matter being, in all probability, manganese and iron. The finest specimens are from Brazil, Ceylon, India, Siberia, Persia, and Spain. It is found also less transparent and well coloured in almost every country of Europe.

British Localities.—Several of the mines of Cornwall; the traps of Fifeshire, and of Kinnoul Hill, in Scotland; the neighbourhood of Cork, and Achil Island, county of Mayo, Ireland.

YELLOW QUARTZ.—*The Bohemian Topaz*, of various shades of yellow, and nearly transparent, is found chiefly in Bohemia; also in some of the mines in Cornwall; and with brown quartz at Cairngorm, in Aberdeenshire.

BROWN OR SMOKE QUARTZ, OR CAIRNGORM is found in several parts of Europe; some fine crystals, of various shades, are from alluvial soil near Cairngorm, whence one of its names.

PRASE.—Quartz coloured leek-green by an admixture of chlorite, from Breitenbrun, in Saxony; also from Iona, one of the Hebrides.

AVANTURINE.—Quartz enclosing mica. The finest varieties are from Spain, and are of a reddish colour, inclosing spangles of mica of a golden hue. It is found in Glen Fernat, in Scotland, of a fine blueish-gray colour.

FERRUGINOUS QUARTZ, OR EISENKESET.—Colour, different shades of red and yellow, derived from a small portion of oxide of iron. It occurs, both crystallized and massive, in Bohemia, Franconia, the Hartz mountains, and Altenberg, in Saxony.

British Localities.—Bristol; trap rocks near Dunbar; and Rathlin Island, on the coast of Antrim. A fine crystallized variety called the *Hyacinth of Compostella*, occurs near Compostella, in Spain, and in Washington county, North America.

IRISATED QUARTZ.—Shows a prismatic play of colours, either *superficial or internal*. The former is occasioned by the deposit of some metallic oxide, the latter by the refraction of light, in consequence of fissures in the crystal.

Fibrous Quartz.—Common quartz sometimes shows a columnar composition. If these columns be thin, parallel, strongly coherent, and more or less bent, the variety is called *fibrous* quartz. If they are nearly impalpable, and scarcely to be observed, except in the opalescent light exhibited when cut with a convex surface, the specimen is called *cat's eye*.

Chert, or hornstone, flint, flinty slate, Lydian stone, calcedony, carnelian, agate, chrysoprase, plasma, heliotrope, and jasper, are massive varieties of quartz, occasioned by differences in the size and mode of aggregation of the component parts, or by the admixture of other earths. Jasper consists of quartz, alumina, and oxide of iron, and sometimes constitutes beds of considerable extent.

Felspar.

Next to quartz and oxide of iron this is the most generally diffused of any mineral. It occurs in rhomboidal crystals, in granite, porphyry, trachyte, and basalt; in composite crystals in cavities in granite; in rolled crystals in conglomerates; decomposed in porcelain clay; and in some granites and sandstones. It admits of cleavage, with greater or less facility, into an acute-angled parallelopipedon, which is considered the primary form.

Fracture, in one direction lamellar; cross fracture uneven:——*Lustre*, vitreous, inclining to pearly on the lamellar fracture—that of the cross fracture glimmering:——*Hardness*, scratches glass; yields with some difficulty to the knife:——*Colour*, the prevailing colour is white; sometimes flesh-red, and green:—*Streak*, white, or grayish:—*Specific gravity*, 2·54:——*Composition*, according to an analysis by Klaproth, of common felspar from Carlsbad,—silica 64·50, alumina 19·75, potassa 11·50, lime a trace, oxide of iron 1·75, water ·75.

Labradorite, or Opalescent Felspar, is of a smoke-gray colour, and affords beautiful and varied tints of blue, green, red and yellow, when viewed in particular directions.

Structure, lamellar:——*Transparency*, transluscent at the edges:——*Lustre*, glimmering:——*Composition:* it differs from common felspar in containing soda instead of potassa.

Compact Felspar.

The substance called compact felspar appears to require some other name. It approaches in composition nearer to labradorite than to the common felspar, containing soda as well as potassa. It occurs in large masses, both as a simple rock, and entering as an ingredient into a number of compound rocks. As a simple rock it is thus described by Dr. M'Culloch:—"Colour, various shades of green, brown red, pale gray, white, dark gray, purple, and black The fracture is compact, uniting the small splintering with the flat or imperfectly conchoidal. It is less hard than quartz, but resists ordinary steel. It generally possesses a peculiar aspect on the surface resembling that of wax, which is highly characteristic; and it may assist beginners to say that, except in hardness, and refusing to effervesce with acids, it very strongly resembles in external characters many of the compact and smooth varieties of limestone[*]." It occurs in gneiss in large flattened masses or beds like the beds of limestone in the same situation, and in smaller lumps, or contemporaneous veins, as they are sometimes called, originating and terminating in the mass in which they lie; also as single laminæ in gneiss possessing the granitic or schistose character. It constitutes likewise the basis of many of the trap family of rocks. Rocks, consisting principally of compact felspar, may be known by the white appearance they assume on a weathered surface.

Dr. M'Culloch has remarked that, in the trap family, the predominant substance is a simple rock, at one extreme of which may be placed wacke, or indurated clay, and at the other compact felspar, the intermediate members being claystone and clinkstone.

CLINKSTONE.

THIS mineral constitutes, as we have before observed, simple rocks, which are massive, columnar, or with a thick slaty structure; *fracture*, even or imperfectly conchoidal, sometimes splintery. It assumes a granular appearance by weathering, and is destitute of the waxy appearance of compact felspar, which it much resembles. It yields, with greater or less facility, to the knife, as it passes, on the one hand, into compact felspar, and on the other, into claystone. It is of various colours. It emits a ringing metallic sound when struck by a hammer, whence its name. This, however, is by no means a distinctive character, as it is possessed by many other rocks, and by some in a much higher degree.

CLAYSTONE.

THIS substance forms the whole of some, and the greater portion of many other rocks. It occurs in various degrees of induration, from wacke, the softest of the trap family, to jasper and siliceous schist, the hardest of rocks.

MICA.

THIS mineral occurs confusedly crystallized as one of the constituents of granite, gneiss, and mica slate, and as nodules and concretions in those rocks; crystallized in hexagonal plates in granite, porphyry, lava, and primary limestone; as abraded scales in sands, sandstones, shales, and clays.

Its primary *form* is considered to be a right rhomboidal prism, the angles of which are 60° and 120°.

Colour, various shades of white, yellow, green, brown, and occasionally black:——*Cleavage:* mica is easily divided parallel to the terminal planes of its crystals:——*Fracture*, scarcely observable, uneven:——*Lustre*, vitreous, pseudo-metallic:——*Transparency*, sufficiently transparent in thin plates to be used as a substitute for glass:——*Touch*, smooth, but not unctuous:——*Hardness*, yields readily to the knife, but the edges of the crystals will scratch glass:——*Powder*, grayish-white:

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[*] M'Culloch's *Classification of Rocks*.

——*Elasticity:* this quality distinguishes it from talc, which is flexible, but not elastic:——*Specific gravity*, about 2·0 to 2·5:——*Before the blowpipe*, mica from different localities varies considerably in its pyrognostic characters, but is in general fusible with difficulty into a gray or black enamel.

Composition. The analyses of several varieties of mica from different localities, by Klaproth, Rose, and Peschier, give very different results, as will be seen from the following table*:—

INGREDIENTS.	Mica from Zinnwald.	From Siberia.		From St. Gothard.	From Kimito.
Alumina	20·00	34·25	22·00	0·00	36·80
Silica	47·00	48·00	40·25	19·50	46·36
Oxide of iron . . .	15·50	4·50	8·75	26·50	4·53
Oxide of titanium .	0·00	0·00	13·00	25·40	0·00
Oxide of manganese .	1·75	a trace.	2·00	25·25	0·00
Magnesia	0·00	0·50	0·00	0·00	a trace.
Lime	0·00	0·00	1·75	0·00	0·00
Potassa	14·50	8·75	7·25	0·00	9·22
Fluoric acid and water	0·00	0·00	3·24	0·00	1·81
	Klaproth.	Klaproth.	Peschier.	Peschier.	Rose.

TALC.

TALC is very closely allied to mica; it occurs crystallized in some granites, massive and earthy in veins in talcose schists and primary limestones.

CRYSTALLIZED TALC.

Form of crystals, hexagonal tables. The primary is a right rhomboidal prism of 120° and 60°, according to Haüy:——*Structure* lamellar, the laminæ easily separated:——*Colour*, silver white, yellowish, and of various shades of green:——*Lustre*, splendent, pearly:——*Transparency*, translucent:——*Hardness*, yields to the nail, soft, sectile:——*Flexibility*, flexible, but not elastic:——*Streak*, leaves a pearly white streak when drawn over paper:——*Touch*, unctuous:——*Specific gravity*, 2·8.

Before the blowpipe specimens from different localities vary much in their habitudes. In general talc whitens and exfoliates, but does not fuse; but some varieties yield, with difficulty, a white enamel.

Composition. This likewise varies with the locality of the specimen. According to Klaproth, it consists of silica 61·00, magnesia 30·55, potassa 2·75, oxide of iron 2·50. The analysis of Vauquelin afforded no potassa.

MASSIVE TALC is less flexible and translucent than common talc, colour apple-green, structure sometimes radiated. It constitutes extensive beds in mica, schist, gneiss, and serpentine.

British localities, Banffshire and Aberdeenshire; also Glen Tilt in Perthshire; Lizard Head, Kyaris Cove, and Porthallo in Cornwall.

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* From Moh's *Treatise on Mineralogy*.

Indurated Talc, massive, of a greenish-gray colour; structure schistose and curved, shining, and of a pearly lustre, somewhat translucent, soft and unctuous. Specific gravity, 2·9.

British localities, Perthshire, Banffshire, the Shetland Isles, and the Lizard in Cornwall.

CHLORITE.

Chlorite occurs crystallized in veins and in cavities in granite, &c., enclosed in crystals of quartz, felspar, and other minerals, in such quantities as to impart a green colour to them, sometimes coating the surface; massive in chlorite schists and clay slates.

Crystallized Chlorite. *Form*, flat six-sided prisms, divisible into thin laminæ parallel with their terminating planes:——*Colour*, dark green, yellowish green, and grayish:——*Lustre*, shining, between pearly and vitreous:——*Transparency*, opaque:——*Fracture*, uneven:——*Hardness*, yields to the nail:——*Powder*, greenish-gray:——*Touch*, unctuous:——*Odour*, yields an earthy smell when breathed upon.

Before the blowpipe, in the matrass alone, gives off water and afterwards fluoric acid, known by its turning Brazil-wood paper yellow, and by depositing silica on the glass. On charcoal *alone* it melts into a black globule with a dull surface. With *borax*, gives a green glass; with *microcosmic salt*, decomposes, forming a glass coloured by iron, and leaving a skeleton of silica. With *soda*, neither fuses nor intumesces, but the assay is rounded on the edges.

Earthy Chlorite occurs in friable or loosely aggregated grains, adhering or incrusting.

Common, or Massive Chlorite, is the same as the last, but the grains are more closely united, of a weakly glimmering lustre and earthy texture.

White Silvery Chlorite.—Pearly, greenish-white scales, occurring in masses, but adhering so slightly as to be separated by the finger.

Chlorite Slate.—Structure slaty, of a glistening resinous lustre. It occurs in beds in St. Gothard, Saltzburg, Sweden, Corsica, Jura, Anglesey, and part of Caernarvonshire.

Green Earth, a variety of chlorite, found in small globular masses, lining cavities in amygdaloidal trap. Colour grayish or blueish-green, passing into blackish-green——*Lustre*, dull:——*Fracture*, generally earthy:——*Hardness*, yields to the nail. It is found in Saxony, Bohemia, near Verona, Kinnoul Hill, near Perth, and in the amygdaloidal traps of the county of Antrim.

The greenish masses in the sand beneath the chalk of England, known by the name of the green sand, are considered to belong to a variety of this mineral. The following table shows the difference in composition of some of these chloritic minerals, according to the analysis of Vauquelin.

	Earthy Chlorite.	Slaty Chlorite.	Green Earth.
Silica	26·00	29·50	52·00
Magnesia	8·00	21·39	6·00
Oxide of Iron	43·00	23·39	23·00
Alumina	18·05	15·62	7·00
Water	——	7.38	4·00
Potassa	2·00	0·00	7·50
Lime	0·00	1·50	0·00

HORNBLENDE, OR AMPHIBOLE.

THIS mineral occurs crystallized with felspar, quartz, in some granites, in syenite, greenstone, basalt, and lava; also in hornblende rock, and hornblende slate.

Form of the crystal.—The primitive form, ascertained by Haüy, by reflection on fragments, is an oblique rhomboidal prism of 124° 36′ and 55° 24′. It occurs occasionally in rhomboidal crystals, but more frequently confusedly aggregated; sometimes the crystals are long, flat, six-sided, and prismatic, and are often striated longitudinally:——*Colour*, dark bottle-green, brownish-green, or brown, approaching to black:——*Lustre*, shining:——*Transparency*, the dark varieties opaque, the green varieties translucent at the edges:——*Fracture*, crystalline, exhibiting fibres confusedly aggregated:——*Hardness*, yields easily to the knife:——*Frangibility*, tough, and difficult to break;—indented by the hammer:——*Powder*, greenish-gray:——*Specific gravity*, 3·6:——*Before the blowpipe*, melts easily into a black glass.

MASSIVE HORNBLENDE is of a crystalline structure, composed of long crystals, intersecting each other, sometimes confusedly radiated. It frequently has a ferruginous appearance on the surface from decomposition.

Hornblende slate differs only from the massive, in having a schistose structure.

BASALTIC HORNBLENDE generally occurs in single crystals, and is sometimes magnetic. The primitive form of the crystal is the same as that of common hornblende. It is of a black colour, vitreous lustre, and hard enough to scratch glass. Its specific gravity is 3·25.

The composition of common and basaltic hornblende, according to Klaproth, is given below:

	Common Hornblende.	Basaltic Hornblende.
Silica	42·00	47·00
Alumina	12·00	26·00
Lime	11·00	8·00
Magnesia	2·25	2·00
Oxide of Iron	30·00	0·00
Iron	——	15·00
Ferruginous Manganese	0·25	
Water	0·25	

Common hornblende is found in a great variety of rocks, and often enters largely into their composition. Its British localities are Mullyan Cove, Cornwall, in greenstone; abundantly in the traps, greenstones, and basalt of the coal measures, and of the slate mountains of the Cambrian and Cumbrian chains; in the syenites, mica slate, and gneiss of Scotland and Ireland, and in the trap rocks of those two countries. Basaltic hornblende occurs in the basaltic rocks of most parts of Europe.

AUGITE, OR PYROXENE.

AUGITE occurs crystallized with felspar in augitic greenstone, augitic basalt, and lava, and in primary limestone.

Form of the crystal.—The primary form, according to Haüy, is an oblique rhomboidal prism, of 87° 5′ and 92° 55′. It is generally found in small crystals, of six and eight sides, terminated by diedral summits. It also occurs in grains and amorphous:——*Colour*, usually dark green, brown, and sometimes black:——*Lustre*, vitreous:——*Fracture*, conchoidal:——*Hardness*, scratches glass, and sometimes gives sparks with steel:——*Specific gravity*, 3·3:——*Before the blowpipe*, melts with great difficulty, and only in minute portions, into a black enamel. Its difficulty of fusion is one character by which it is distinguished from hornblende, which it much resembles: the difference in the angles of the primitive forms of the two minerals is another.

Hornblende and augite are very closely allied. Crystals possessing the form and structure of augite, were observed by Mitscherlich, in the slags of many founderies in Sweden and Germany; and on fusing in a porcelain furnace a mixture of silica, lime, and magnesia, in the proportions in which they are found in augite, crystals were produced, having the form and structure of augite; but crystals of hornblende could not be obtained by a similar process. Professor Rose accounted for the production of augite, and non-production of hornblende, by attributing it to the effect of rapid cooling; and this conjecture he confirmed, by fusing, in a platinum crucible, a light green variety of hornblende, which, on cooling, formed fibrous tufts of dark crystals, which admitted of measurement by Wollaston's reflecting goniometer, and were found to have the angles of augite. A specimen of diopside, a green translucent variety of augite being submitted to the same process, cooled into a dark mass, but regained its former structure. Augite, therefore, is formed when the process of cooling is rapid, and hornblende when it is slow. The localities in which these two minerals are found, are another proof of this. Hornblende is usually found in syenite, trachyte, and lava, accompanied by quartz, felspar, and albite, minerals which require for their formation a slow process of cooling; while augite occurs in basalt and lava, in company with olivine, which was also recognised in the scoriæ of several founderies. A fact observed by Von Buch, that those lavas which contain felspar have hornblende but no augite, is thus accounted for.

ACTYNOLITE.

THIS mineral occurs in veins in hornblende, slate, gneiss, mica slate, and limestone. It is of a pale green colour, and may be divided into three varieties,—crystallized, asbestiform, and glassy, actynolite.

CRYSTALLIZED ACTYNOLITE.—*Form*, single prisms, or columnar masses, consisting of hexahedral prisms:——*Colour*, leek-green:——

Fracture, fibrous and scopiform :——*Lustre*, shining, sometimes silky: ——*Transparency*, varies from translucent to transparent:——*Hardness*, scratches glass:——*Specific gravity*, 3·3:——*Composition*, according to Bergman, silica, 64·00; alumina, 2·70; lime, 9·30; magnesia, 20·00; oxide of iron, 4·00:——*Before the blowpipe*, it melts into a greenish-gray glass.

ASBESTIFORM ACTYNOLITE.—*Form*, massive, and in capillary crystals, disposed in wedge-shaped masses, or in radii, which are green, greenish-gray, and brownish-green, opaque, or slightly translucent at the edges: ——*Composition*, nearly the same as the preceding.

GLASSY ACTYNOLITE differs from the asbestiform in having an external lustre, vitreous, inclining to pearly, and in being translucent and brittle.

Actynolite is found in the Tyrol, in St. Gothard, near Salzburg, in Norway, and in Piedmont. *British localities*, near Lostwithiel, and St. Die, in Cornwall, in copper and tin veins, and at St. Michael's Mount, in asbestiform rocks; at Llanberris, Caernarvonshire, in greenstone; in globular concretions in the amygdaloid of Caer Caradoc, in Wales, and in the Isle of Lewis.

HYPERSTHENE.

HYPERSTHENE occurs crystallized with felspar in hypersthene rock, hypersthenic syenite, hypersthenic greenstone, and hypersthenic granite: *Structure*, lamellar:——*Cleavage*, parallel to the sides of a quadrangular prism of about 93°, more perfect parallel to the short diagonal of that prism; traces of cleavage parallel to the long diagonal:——*Colour*, dark brown, or greenish black:——*Lustre*, on the fractured surface, pseudo-metallic, of a copper red, or a greenish colour, observable in one direction, but not in the other:—*Transparency*, opaque:——*Hardness*, yields to the knife:——*Powder*, dark gray:——*Specific gravity*, 3·38:——*Fracture*, uneven:——*Composition*, by Klaproth's analysis: silica 54·25, alumina 2·25, lime 1·25, magnesia 14·00, oxide of iron 34·50, water 1·00, with a trace of oxide of manganese:——*Before the blowpipe*, heated *alone*, it is but little altered, but upon charcoal melts into a greenish-gray opaque globule, easily soluble in borax. This mineral was first discovered in rolled masses on the coast of Labrador, and thence called Labrador hornblende. It also occurs in a rock analogous to syenite or greenstone, consisting chiefly of Labrador felspar. It has been observed in serpentine, in Coverack Cove, in Cornwall.

DIALLAGE.

THIS mineral occurs crystallized with felspar in diallage rock: obscurely crystallized and fine grained in serpentine.—*Cleavage*, in two directions, in one the cleavage is highly perfect, and easily obtained; the other appearing only in slight traces:——*Colour*, olive green, inclining to blackish green:——*Lustre*, inclining to metallic, on the perfect faces of cleavage, vitreous on the other faces:——*Transparency*, opaque, translucent on the edges:——*Hardness*, yields to the knife:——*Powder*, greyish white:——*Specific gravity*, 3·1:——*Composition*. Its constituents, according to the analysis by Bonsdorf, are—

	A Green Variety.	A Black Variety.
Silica	46·26	45·69
Magnesia	19·03	18·79
Lime	13·96	13·85
Alumina	11·48	12·18
Protoxide of Iron	3·43	7·32
Protoxide of Manganese	9·36	0·22
Fluoric Acid	1·60	1·50
Water and foreign substances	1·04	0·00

Before the blowpipe, it fuses with some difficulty into a blackish enamel.

The foreign localities of diallage are Basta in the Hartz, in greenstone; Zöoblitz in Saxony, Salzburg, and the Tyrol, in serpentine. Its British localities are the Isle of Anglesey, Coverack Cove, and near St. Keverne, in Cornwall; between Ballantrae and Girvan, in Ayrshire; and at Portsoy, in Banffshire, in serpentine; in Fifeshire, in greenstone rocks; and in porphyritic rocks in Calton Hill, and Dunbarton.

STEATITE, OR SOAPSTONE.

STEATITE is found in considerable masses and beds in serpentine, granite, clay slate, and also in veins.—Serpentine is the rock in which it usually occurs.

Form, massive. In Franconia it occurs with occasional appearances of crystallization, which are generally considered pseudo-morphous, resembling the forms of the quartz or carbonate of lime with which it is associated:——*Colour*, white, passing into gray, green, yellow, and red: ——*Lustre*, dull—lustre of the streak faintly resinous:——*Fracture*, uneven, splintery:——*Hardness*, yields to the nail, sectile:——*Touch*, unctuous, does not adhere to the tongue:——*Transparency*, somewhat translucent at the edges:——*Specific gravity*, 2·67:——*Composition*. We give the results of an analysis by Vauquelin, and of two others by Klaproth, of steatite from different localities:—

		From Baireuth.	From Cornwall
Silica	64·00	59·50	45·00
Magnesia	22·00	30·50	24·75
Alumina	0·00	0·00	9·25
Oxide of Iron	3·00	2·50	1·00
Water	5·00	5·50	18·00
	Vauquelin.	Klaproth.	Klaproth.

Before the blowpipe, it hardens and blackens, but is infusible.

Steatite occurs at Freyberg, and in the principality of Baireuth, in Saxony; in Bohemia, Norway, Sweden, and France; also in Maryland, Pennsylvania, and Connecticut, in North America. The British localities are, in serpentine, the serpentine districts of Cornwall and Anglesey, and at Portsoy, in Scotland; in wacke, in the Isle of Skye, and others of the Hebrides.

SERPENTINE.

SERPENTINE often constitutes masses of simple rock, and is found sometimes intermixed with crystalline limestone, constituting the marble known by the name of Verde Antique; but it enters into the composition of no other mixed rocks, except as rolled masses in conglomerates. From the great variations in its composition, it ought to be regarded rather as an indefinite earthy compound than a simple mineral. Mineralogists divide serpentine into two kinds, Noble and Common. Noble Serpentine occurs massive; fracture splintery, passing into conchoidal; colour, various shades of green, and yellowish green; translucent lustre glimmering or glistening, resinous; somewhat unctuous to the touch; yields to the knife; sectile; powder white; specific gravity 2·5;—*Composition.* The first analysis is by Hisenger, the second by John:—

Silica	32·00	42·50
Magnesia	37·24	38·63
Alumina	0·50	1·00
Lime	10·20	0·25
Oxide of Iron	6·00	1·50
Oxide of Manganese	0·00	0·62
Oxide of Chrome	0·00	0·25
Water	14·00	15·20

NOBLE SERPENTINE is found in beds and masses in primary limestone, gneiss, and mica slate. It occurs in Italy, Silesia, Sweden, Bohemia, and the Tyrol; at Connecticut, and Newbury Point, Massachusetts, in crystalline limestone. *British localities*, in the marble of Glen Tilt, in Scotland; in veins, in common serpentine, in the Isle of Anglesey, and Cornwall, and in the county of Galway, Ireland.

COMMON SERPENTINE is of various shades of green, brown, and red, the brown most prevalent,—the colours variously intermixed and blended in stripes and blotches. Fracture uneven, occasionally approaching the flat conchoidal, generally dull and opaque, sometimes translucent at the edges; hardness variable, sometimes scarcely yielding to the knife. Before the blowpipe, noble and common serpentine in the *matrass* give off water and blacken; on *charcoal*, turn white, and, in a good heat, melt on the thin edges into an enamel; with *borax*, melt slowly into a clear green glass.

The localities for common serpentine are the same as for the preceding variety, and also the following: Portsoy, Banffshire; and at the Bridge of Corlachie, Forfarshire; in Ayrshire; near Burnt Island, Fifeshire; in the Shetland Isles, Unst and Fetlar; and in Glass, one of the Hebrides.

CARBONATE OF LIME.

THIS mineral, which is so generally diffused, enters but sparingly into compound rocks, as one of their ingredients. In them it occurs chiefly as veins, but considerable masses of it form particular beds in other rocks, or constitute rocks themselves. It is more abundant in the more recent than in the older stata. It is found crystallized in veins, cavities of rocks, fossil remains, and stalactites, and in beds of primary limestone; it occurs also massive and amorphous, (its most common form,) as limestone strata. The crystalline varieties of limestone generally occur in the older rocks, the compact and earthy varieties in the more modern; it occurs also concretionary in oolites; fibrous in some limestones and organic remains; as nodules in amygdaloidal traps; lamellar in organic remains; earthy and pulverulent in chalk, marl, and some kind of limestone.

Form.—Crystals of calcareous spar, or pure carbonate of lime, are found under a great variety of forms, all resolvable, by cleavage, into an obtuse rhomboid of 105° 5′ and 74° 55′:——*Fracture.* The cross fracture is conchoidal, but not easily obtained:——*Colour*, various:—— *Lustre*, between pearly and vitreous:——*Transparency*, more or less transparent; the purer varieties refract doubly:——*Hardness*, yields easily to the knife:——*Powder*, grayish-white:——*Specific gravity*, 2·7:—— *Composition.* Lime 57; carbonic acid 43. It effervesces in acids from the disengagement of carbonic acid gas:——*Before the blowpipe*, all varieties of carbonate of lime exhibit the following characters: are infusible alone on charcoal, do not colour the flame of the blowpipe, but shine with great brightness when the carbonic acid is driven off. By calcination they lose about 43 per cent. of this; the calcined mass becomes caustic, disengages heat when moistened with water, and has an alkaline reaction on test papers. With the *fluxes*, carbonate of lime dissolves with effervescence and fuses into a glass, transparent while hot, milky when cold. Carbonate of lime is so generally diffused that no list of localities can be given. The most rare and beautiful varieties of calcareous spar are derived from Derbyshire and the North of England; while in Cornwall it is extremely rare.

Carbonate of Magnesia.

Magnesite, or carbonate of magnesia, occurs amorphous, fibrous, and spongiform, also pulverulent:——*Colour*, gray or yellowish, with dendritic delineations:——*Fracture*, splintery or flat conchoidal:—— *Lustre* and *transparency*, dull and opaque:——*Hardness*, yields to the nail externally, internally is harder than calcareous spar:——*Touch*, meagre; adheres to the tongue:——*Specific gravity*, 2·8:——*Composition.* According to an analysis of a specimen from Styria, by Klaproth, its constituents are, magnesia 48, carbonic acid 49, water 3. It dissolves with slow effervescence in acids, yielding, with sulphuric acid, crystals of sulphate of magnesia:——*Before the blowpipe*, it crackles, shrinks, and hardens on charcoal, and then has an alkaline reaction on test papers.

It is found in Moravia and Styria, and at Baudissero and Castellamonte, in Italy; at Vallecas, in Spain; Baumgarten, in Silesia; and near Baltimore, North America, all in serpentine.

Carbonate of magnesia, combined with carbonate of lime, occurs crystallized, under the name of bitterspar, in veins, in chloritic rocks, serpentine, dolomite, and magnesian limestone.

Bitterspar.

Form, a rhomboid, differing from that of carbonate of lime in the value of its angles, which are 106° 15′, and 73° 45′ by the reflecting goniometer. This is the primary form, to which other varieties of its crystals may be reduced by cleavage:——*Colour*, grayish, or yellow, sometimes inclining to green or red:——*Lustre* and *Transparency*, pearly, semitransparent:——*Fracture*, foliated:——*Hardness* and *Frangibility*, scratches calcareous spar, brittle:——*Powder*, grayish-white:——*Specific gravity*, 3·0:——*Composition*, 52·0 carbonate of lime, 45·0 carbonate of magnesia, 3·0 oxide of iron and manganese. It dissolves slowly, and with very little effervescence, in cold, but more rapidly in hot, acid, effervescing considerably:——*Before the blowpipe*, it is not to be distinguished from calcareous spar.

It occurs in the mountains of the Tyrol and Salzburg, in the mountains of Taberg, in Sweden, and of Chalance, in Dauphiny: in Scotland, on the borders of Loch Lomond, in chlorite schist, and near Newtown Stewart, in Galloway; also in the Isle of Man, in compact dolomite, and in the magnesian limestone of the north of England.

DOLOMITE.

A MASSIVE variety of the carbonite of lime and magnesia, resembling granular limestone, but much softer.

Structure, consisting of fine grains, which are lamellar:——*Colour*, white, sometimes with a tinge of green or gray:——*Lustre* and *Transparency*. Internal lustre glistening, translucent at the edges:——*Hardness*, yields to the nail:——*Phosphorescence*, frequently emits a phosphorescent light when struck in the dark:——*Specific gravity*, 2·8:——*Composition*, 59· carbonate of lime, 40· carbonate of magnesia.—Its action with acids and before the blowpipe has been described under bitterspar.

Dolomite occurs in Sweden, France, Saxony, the Pyrenees, Apennines, &c. It is also found in the island of Iona, in a bed about forty feet wide, in hornblende rock.

MAGNESIAN LIMESTONE occurs abundantly as a rock formation in England, ranging from Nottingham to Sunderland. It is likewise found in beds in the Mendip Hills, and in the carboniferous limestone series near Bristol, and Ballyshannon and Howth, in Ireland.

It differs from common limestone in having a granular sandy structure, a glimmering or glistening lustre, and a yellowish colour. Its characters with acids and before the blowpipe are the same as those of dolomite. It consists, of lime about 30·, magnesia 21·, carbonic acid 47·, clay and oxide of iron 1.

SULPHATE OF LIME.

SULPHATE of lime occurs crystallized in beds of clay, under the name of selenite; fibrous, compact, and pulverulent, under the name of *Gypsum*.

CRYSTALLIZED GYPSUM, or SELENITE:——*Form*. It occurs generally in flat crystals, which are oblique parallelopipedons. The primary form is considered by Haüy to be a right rhomboidal prism, the bases of which are oblique-angled parallelograms of 113° 8′ and 66° 52′:——*Structure*, lamellar, the cleavage in one direction perfect and easily obtained; but imperfect and obtained with difficulty in the others:——*Colour*, various shades of white, gray, and brown; sometimes colourless, and highly transparent:——*Lustre*, shining, pearly:——*Transparency*, more or less transparent:——*Hardness*, yields to the nail, sectile:——*Flexibility*. Divided into thin laminæ it is flexible, but not elastic:——*Specific gravity*, about 3·0:——*Composition*, lime 32·7, sulphuric acid 46.3, water 21.—Before the blowpipe, it gives off water in the matrass, and becomes friable. If reduced in this state to an impalpable powder, and mixed with water, it evolves heat, and soon hardens into a solid mass. Held in the forceps, and urged with a stronger flame, it exfoliates, and melts, though with some difficulty, into a white enamel.

Selenite is found in almost every country in Europe. In England it occurs in the London clay, and in another clay, lower in the series of rocks, called the Oxford clay. From the pits at Shotover Hill, near Oxford, very beautiful crystals are obtained.

FIBROUS GYPSUM, a very beautiful mineral, occurs massive, composed of delicate and nearly separate fibres, either straight or curved:——*Colour*, generally white, but various, like that of selenite:——*Lustre*, glistening, pearly; translucent; cross fracture, lamellar, and very brilliant; yields to the nail. It occurs at St. Gothard, in beds, in gneiss; in the Valais in hornblende slate; in several countries of Europe and America in the fossiliferous series.

COMPACT GYPSUM, OR ALABASTER.

MASSIVE, fracture compact, or slightly splintery:——*Lustre*, dull, or glimmering, translucent at the edges;—yields to the nail. Its colours are nearly the same as those of selenite, but it sometimes occurs mottled. It is met with in several countries of Europe and North America. In England it occurs in Derbyshire.

BITUMEN.

THERE are three varieties of bitumen: earthy bitumen, or mineral tar; elastic bitumen, or mineral caoutchouc; compact bitumen, mineral pitch, or asphaltum. Bitumen occurs solid or liquid in some limestones, and in organic remains and veins; also disseminated invisibly through the substance of beds of coal, and of certain shales and limestones.

EARTHY BITUMEN.—Amorphous, earthy, blackish brown, dull, sectile, very soft, taking an impression from the nail, possesses the peculiar odour known as the bituminous; burns with a brisk clear flame, and an agreeable smell, with the deposit of much soot. It is found in France, Persia, the Hartz.

Earthy bitumen occurs in nodular masses of various shades of brown; soft, yielding easily to pressure; flexible, elastic, sectile, of a strong bituminous odour, burns with a strong flame and much smoke, melts at a gentle heat. Specific gravity, about 1·0. It removes the traces of a pencil on paper like caoutchouc or Indian rubber, whence its name of mineral caoutchouc. Elastic bitumen consists chiefly of bituminous oil, hydrogen, and charcoal. It has hitherto been found only at Castleton, in Derbyshire.

COMPACT BITUMEN—ASPHALTUM.

MASSIVE. Colour, brownish-black, to black; fracture, conchoidal, brittle. Lustre, shining; resinous; opaque; gives out the bituminous odour when rubbed. Specific gravity, 1·0 to 1·6. It burns freely, leaving a small quantity of ashes. It consists chiefly of bituminous oil, hydrogen, and charcoal, the latter being in much greater proportion than in the preceding variety. Oxide of iron, and two or three of the earths, are sometimes present in small quantities. It is found in France; at Neufchatel, in Switzerland; in large strata at Aolona, in Albania; in lumps on the shores, or floating on the lake in Palestine, called the Dead Sea. It is obtained in large quantities from the islands of Barbadoes and Trinidad; in the latter in such profusion as to be used mixed with grease for dressing the bottoms of ships.

OXIDE OF IRON.

OXIDE of iron occurs crystallized in lava, syenite, and hypersthene rock, and minutely disseminated through sandstones, clays, ironstones, ochres, and almost every rock.

Crystallized Oxide of Iron, Iron Glance, Specular Iron:——Form, lamellar, and crystallized in various shapes, the primitive being a slightly acute rhomboid of 87° 9′, and 92° 51′:——*Structure*, lamellar:——*Fracture*, cross fracture uneven, passing into conchoidal:——*Colour*, deep steel gray:——*Lustre*, splendent, metallic, frequently tarnished, and beautifully iridescent:——*Transparency*, opaque in large fragments, but the edges of thin small ones are blood-red by transmitted light:——*Hardness*, scratched by the knife:——*Powder*, cherry-red, slightly *magnetic* when pulverized:——*Specific gravity*, 5·0:——*Composition:* it consists entirely of peroxide of iron:——*Before the blowpipe*, it is infusible without the addition of fluxes, but becomes magnetic:——Colours glass of borax a dirty yellowish green. It occurs in veins and beds in the older rocks. Among other localities it is found in great abundance, and in crystals of great beauty, in the Isle of Elba, the iron mines of which have been worked from a very remote antiquity. It is found in Saxony and Bohemia in mica schist; at the foot of the great St. Bernard; at Maryland in gneiss; and in South America and Siberia. In Britain it occurs finely crystallized in St. Just, and Tin Croft mine, in Cornwall, in clay slate; at Cumberhead, in Lanarkshire: at Eskdale, in Cumberland, and various other localities.

VOLCANIC IRON GLANCE occurs in very flat crystals, often with curvilinear faces intersecting each other. It is less splendent than the last.

MICACEOUS IRON GLANCE.—Minute shining scales, either loose or slightly cohering. Colour, by reflected light, iron black, with occasionally a tinge of red; by transmitted light, of a blood-red colour.

SULPHURET OF IRON, OR IRON PYRITES.

SULPHURET of iron occurs in veins and beds, also disseminated through clay slates and primary limestones and shales. It is found amorphous, mammillated, globular, cellular, stalactitical, pseudo-morphous, capillary, and crystallized in the cube and octohedron. It is found also enclosed in other minerals, and investing them. The organic remains of some shales and clays are mineralized by it.

Form: the octohedron may be considered the primary form, but common pyrites has no regular cleavage:——*Fracture*, granular or uneven, sometimes appoaching conchoidal:——*Colour*, brass yellow, inclining sometimes to greenish yellow and steel gray:——*Lustre* and *Transparency*, metallic, opaque:—— Hardness and *Frangibility*, brittle, but does not yield to the knife; scratches glass.

This character distinguishes it from sulphuret of copper:——*Powder*, brownish black:—— *Specific gravity*, 4·6 to 4·8:——*Composition*, iron 47·85, sulphur 52·15:——*Before the blowpipe*, it melts, giving out a sulphureous odour, and leaving a blackish slag, which is magnetic. It is universally diffused.

SCHORL.

THIS mineral is met with amorphous, crystallized, and disseminated. It occurs in Cornwall, crystallized with quartz, in so large a proportion as to form one of the constituents of a rock called schorl rock, which has the same geological relations as granite.

Form.—The common form of the crystals is a prism of many sides, generally striated longitudinally, rarely terminated at each end by three planes, also acicular crystals parallel or divergent:——*Colour*, black, and brownish black:——*Lustre* and *Transparency*, glistening, vitreous, opaque:——*Fracture* and *Frangibility*, fine grained, uneven, sometimes conchoidal, fragile:——*Electricity*, becomes electric by being heated, and acquires polarity:——*Specific gravity*, 3·2:——*Before the blowpipe*, schorl fuses *alone*, with strong intumescence, and turns white; the intumesced portion afterwards melting with difficulty into a translucent, grayish-yellow bead. With *borax*, it effervesces and melts into a clear glass with a tinge of iron. With *microcosmic salt*, it effervesces briskly, leaving a skeleton of silica:——*Composition.*—Silica 38, alumina 34, magnesia 1, potassa 6, oxide of iron 21, and a trace of manganese.

TOURMALINE is a finer variety, used in jewellery, of different colours, white, green, yellow, blue, and black; harder and more transparent than common schorl, melting before the blowpipe with greater difficulty, both with and without fluxes, and differing from it slightly in chemical composition.

Localities.—The village of Schorlaw in Saxony, where it was first found; also Bavaria, Bohemia, Switzerland, Spain, Hungary, Asia, and America:——*British Localities.*—Perthshire, Banffshire, Invernesshire, and Argyleshire; near the Land's End in Cornwall; also in the tin veins, and disseminated in the granite rocks of that county; and in the granite of Wicklow and Dublin.

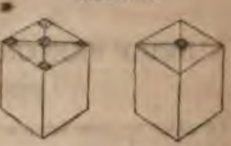
CHIASTOLITE.

CHIASTOLITE occurs crystallized in the clay slates of Cumberland, Spain, Britanny, Ireland, and North America, sometimes in such large quantities as to become a constituent of the rock.

It is a mineral about which little is known. We heard it thus described by Professor Sedgwick, in the Geological Section of the British Association at Dublin:—"That singular mineral, chiastolite, about which all I can tell you is, that I can call it by a hard name, and that I believe is as much as most of my neighbours can do." It is thus described and figured by Phillips:—"It has only been met with in slightly rhomboidal prisms, composed of two distinct substances. The exterior is grayish white, the interior black or blueish black, and its sides are perfectly parallel to those of the exterior substance, which in some specimens are so thin as to form a mere coating. From each of the angles of the interior prism there often proceeds a black line, which sometimes reaches the corresponding angles of the coating, but is sometimes terminated by a black rhomboidal prism, so that the chiastolite occasionally consists of five black rhomboidal prisms communicating by black threads, and, as it were, imbedded in a grayish white or reddish substance which has a lamellar structure, is translucent, and hard enough to scratch glass."

Composition.—Berzelius considers it a compound of silica and alumina:——*Before the blowpipe*, the whitish part of the crystal is infusible, but assumes a whiter tint; a very thin cake made of the powdered mineral concretes into a mass. With *borax*, it melts with difficulty into a clear glass. It gives a blue colour with solution of cobalt. The black part yields a black glass without fluxes:——*British Localities*. The Wolf Crag near Keswick, and on Skiddaw in Cumberland, in clay state; at Aghavanagh and Baltinglass Hill, county of Wicklow, Ireland.

Chiastolite.



GARNET.

GARNETS occur crystallized in granite, gneiss, mica schist, clay slate, primary limestone, near basaltic dikes, and in veins. They sometimes occur in mica slate in such abundance as to equal in quantity the other ingredients of the rock enclosing them. In a bed of green talc, between Styria and Carinthia, the common garnet occurs in crystals of two pounds weight and upwards.

Form, a dodecahedron with rhomboidal planes, which is considered the primitive. It also occurs in crystals, having twenty-four rhomboidal faces:——*Fracture*, conchoidal:——*Colour*, yellowish, greenish, or blackish-brown:——*Lustre*, vitreous, shining:——*Transparency*, opaque, or only slightly translucent. This is the chief point in which common garnet differs from the mineral known as alamandine or precious garnet:——*Hardness*, scratches quartz with some difficulty:——*Composition*, according to Vauquelin, silica 43·0, alumina 16·0, lime 20·0, oxide of iron 16·0.

British Localities. In Cornwall of a red colour in small quantities, in schist and chlorite; north of Keswick, in Cumberland, in a porphyritic felspar; near Huntly in Scotland; in the counties of Wicklow and Donegal in Ireland in granite; in altered shale of the carboniferous limestone series by the side of a basaltic dike near Plas Newydd in Anglesey; and under similar circumstances in shale and limestone altered by a basaltic dike in High Teesdale.

We shall conclude our description of simple minerals entering into the composition of rocks, by recommending the student who may not have the advantage of seeing museums and attending lectures, to purchase a named collection of the minerals we have described, which may be done at a trifling expense. We would urge him not only to look at them, but to try their external characters and habitudes before the blowpipe, comparing them with our descriptions. This will impress them on the memory much more than mere inspection. He will thus become familiar with them, and be able at once to recognise them when he finds them combined in rocks; and the habit of examination thus acquired will render it easy for him to discover, with the assistance of that little book which we have before recommended, those less abundant minerals not here described, some of which he will not fail to meet with the moment he begins to study geology hammer in hand. In studying the external and chemical characters of minerals, it is best to commence on substances with the names and composition of which we are acquainted*.

A BRIEF SKETCH OF ENGLISH SCIENTIFIC LITERATURE,

PRIOR TO THE INVENTION OF PRINTING.

It may appear somewhat presumptuous to attempt, in the short compass of a few pages, even a sketch of the scientific labours of a large kingdom for several centuries, but the materials are so scanty, and the contents of the works now remaining in general so unimportant, that a bare mention is sufficient; and, so far as the credit of the country is concerned, several might be omitted without any detriment.

Of those who flourished before the invention of printing, with the exception of Roger Bacon and John Holywood, there is scarcely a name that would be recognised by the generality of readers. I intend to furnish the reader with all the information I possess on those who are less known, collected principally from the unpublished manuscripts of the British Museum and Bodleian Libraries.

The most ancient work on science by an Englishman that has escaped the ravages of time is, I believe, a translation of *Euclid's Elements of Geometry* from Arabic into Latin, by the celebrated Adelard. Adelard flourished in the first half of the twelfth century; and, besides the *Euclid*, translated several other treatises from the Arabic, one of which, on the Astrolabe, is in the British Museum (MS. Arund. 377). Two manuscripts of the *Euclid* occur in the same library.

Daniel Morley lived towards the close of the twelfth century. He travelled into Spain and Arabia in the pursuit of science. At his return he wrote *Principia Mathematices*. This work is not at present extant, but another treatise by him, mentioned by Bále, occurs among the Arundelian manuscripts (B. M. 377, XVI), entitled *De inferiori et superiori Parte Mundi*, and dedicated to John, Bishop of Norwich. In his dedication, he says that he had departed from England "causâ studii," and made some stay at Paris, from which place he had obtained a great many mathematical manuscripts. The *Almagest* of Ptolemy forms the basis of his treatise. In the MS. he is called Daniel of Merly.

Grostest, Bishop of Lincoln, was born in 1175, and died in 1253. Eight works by him, on the heat of the sun, the utility of the sciences,

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* Errata in the *Popular Course of Geology* in No. XXI.

PAGE	LINE	
175;	5,	*for* lacustine, *read* lacustrine; *for* marl on, *read* marl or.
180,	26,	*for* boundary surfaces, *read* bounding surfaces.
182,	24,	*for* separated again and again, *read* repeated again and again.
182,	30,	*for* animal composition, *read* mineral composition.
183,	3,	*for* their shales, *read* thin shales.
184,	22,	*for* Cambrian, *read* Cumbrian
—	25,	*for* west chain, *read* next chain.
187,	22,	*for* counteracting, *read* countervailing.

&c., were published at Venice in 1514. Two other treatises, *De Impressione Æris*, and *De Quadraturâ Circuli*, are in the Bodleian Library (Digby MSS. 57, 153). He is said to have made a brazen head, which could answer any proposed questions; and, according to Richard of Bardney, the bishop made a journey from England to Rome in the course of one night, by means of an infernal horse of which he had obtained the command.

An intimacy with Roger Bacon is erroneously attributed to Grostest by many writers: so Butler, describing Sidrophel, remarks that,

—— None a deeper knowledge boasted,
Since old Hodge Bacon and Bob Grosted.

For further particulars concerning Grostest, I refer the reader to his life, by Pegge, published at London in 1792.

Of Roger Bacon it is unnecessary to say much. The reader is referred for an account of his works and inventions to Chalmers's *Biographical Dictionary*. Anticipating the mode of investigation perfected by his great namesake, he declared that experimental science alone can ascertain the effects to be performed by the powers of nature or by human art. *That* science alone, he continues, enables us to investigate the practices of magic, not with the intent of confirming them, but that they may be avoided by the philosopher. Thus determined to consider the properties of material substances as matters of fact, and not of belief, he easily ascertained that many of the opinions of former writers were false, and he furnishes instances in support of his general position.

Very few were the men, prior to the sixteenth century, that did not yield to the influence of the prevailing superstition; even Bacon was not entirely free from the infection. Astrological physics afforded a species of compact between fancies and sober reason; the magnet applied to the heart would cure many diseases, and would faithfully disclose the constancy or inconstancy of a wife[*]. Many, indeed, were the cures asserted to be performed by the sovereign remedy of the magnet; which might, perhaps, have formed a stepping-stone, in the shape of a first suggestion, to that climax of absurdities, *animal magnetism*.

John de Hoveden, who flourished about 1275, wrote a small tract on astronomy, the manuscript of which is in the British Museum (MS. Byrch, 1620); it treats on the declination of the sun, milky-way, shadows, the altitude of the sun and moon, &c. About a century after, the poet Chaucer wrote a Treatise on the Astrolabe, *compowned after the latitude of Oxenforde*, for the use of his son Lewis, then ten years of age. The late Reuben Burrow was the first who discovered that it was a literal translation from the Sanscrit of a treatise on the same subject. Chaucer remarks, however, at the end of his preface:—"But considereth well, that I ne usurpe not to have founden this werke of my labour or of mine engine: I nam but a leaud compilatour of the labour of olde astrologiens, and have it translated in mine English, only for thy doctrine: and with this werde shall I sleene envie."

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[*] I make the following extract from a MS. in my possession, on the occult virtues of stones, written somewhere in the fourteenth century:—"If a man wyl prove hys wyfe or hys leman of truthe put yis ston under her hed whan che is on slepe and if che be trewe che sal turne to hymward and if che be nought trewe che sal styrtaway ward as a beste yat is a flayed." The same occurs in a manuscript on precious stones in the British Museum (MS. Arund. 342, fol. 76, b.):—"Magnes est lapis probatus in Jordane inventus ferrei coloris, et ad se trahens ferrum, cum quo mariti probant uxores suas. Sic ponitus super caput dormientis: si casta est super faciem suam vertet; si adultera supina jacebit."

John Holywood, or Johannes de Sacro-Bosco, of Halifax, was cotemporary with Roger Bacon. A curious treatise on arithmetic is attributed to him by some, and by others to Grostest; it thus commences:—

Hæc Algorismus ars præsens qua
Talibus Indorum fruimur bis quinque figuris.
0. 9. 8. 7. 6. 5. 4. 3. 2. 1.
Prima figura unum. duo vero secunda
Tertia significat tria. sic procede sinistre
Donec ad extremam venis. est cyfra vocata.

Two copies of this work are in the British Museum (Casley, 12. E. I. and 12. C. XVII). Professor Peacock is inclined to think that this treatise belongs to the fifteenth century.

William Shirewood, who flourished in the latter half of the thirteenth century, is highly commended by Roger Bacon for his "incomparable skill in the sciences." Richard Suiseth, who lived a century later, wrote treatises on natural philosophy, published at Venice in 1520; and John de Muris, about the same time, wrote a treatise on arithmetic, which contains merely extracts from the work of Boetius, on the same subject. This was published on the Continent in the fifteenth century, in a small quarto volume, without name of printer, date, or place; in this tract he is called John Muris.

With the exception of a single instance, I am not aware of any English scientific work of the middle ages professedly compiled from the Greek. Euclid and Ptolemy were only known through the medium of an Arabic translation. The work to which I refer is one on astronomy, written in the fourteenth century, a copy of which in MS. occurs in the British Museum; a more ancient copy is in my own possession; the commencement is here added:—"Here begynnis ye wyse book of phylosophye and of astronomye conteyned and mad of XX wysest phylysoforys and astronomerys yat ever were syn ye world was begunne. That is for to say in ye lond of grece ffor in yat lond an engelychman ful wys and wel understandyng of phylosophye and astronomye stodyeth and compyled yis book out of grek into engelysch."

There is an anonymous treatise on the music of the spheres, which remains in MS. in several libraries in England, and is considered to be of English authorship. The music of the spheres was one of the Pythagorean absurdities, and currently believed throughout the middle ages; so Chaucer says:—

Then sheweth he him the little earth that here is.
To regard of the heavens' quantitie,
And after showeth he him the nine spheres
And after that the melody heard he.

After a time these superstitions glided away; strange to say, they were revived in the *nineteenth* century by Sydenham and Taylor.

Nicolas of Lynn wrote a calendar calculated for the meridian of *Oxford* (*MS.* Arund. 347); from the prologue, it appears that it was written in the year 1386. Roger of Hereford, in 1178, composed a treatise on the planets (MS. Arund. 377. XV). A treatise of Walter Burley, who flourished in the fourteenth century, on natural philosophy, occurs among the MSS. at Lambeth Palace (No. 556). John de Hexham, John of Salisbury, Clemens Lanthoniensis, and Robert Lorayne, were mathematicians of the twelfth century, whose works I have not met with. The same of the following:—William Sengham, Robert Kilwarby, Thomas Bungy, John Dumbleton, and John Godard, of the thirteenth century; William Slade, Walter Brittle, John Clymarke, Richard Lavingham, William Wodeford, John Somer, Simon of Feversham, Simon of Tunsted, Ludovicus Kaerlon, and Lucas Bosden, of the fourteenth century; and Thomas Walden, William Sutton, and Thomas Norton, of the early part of the fifteenth century.

It will, perhaps, strike the reader as something extraordinary, that among the numerous treatises that have been mentioned, not one occurs on the subject of algebra; the fact is, that it lay dormant for centuries after its introduction, and before the publication of Recorde's *Whetstone of Witte*, in 1557; no proof appears that our ancestors were aware of the existence of such a science. John Dee, even as late as 1570, in the preface to Billingsley's Euclid, mentions his having had the works of Diophantus lent him in 1550, in a manner which shows that they could not have been then generally known. Recorde, at the close of his *Whetstone of Witte*, promised to continue the subject, but his premature death prevented him. The next English work expressly on Algebra, that I am acquainted with, is John Tap's *Pathway to Knowledge*, published in 1621, containing, besides arithmetic, the *Art of Cossike Numbers, drawn out of M. Valentine Menher, his arithmeticke*, written in form of dialogue, evidently in imitation of the *Whetstone of Witte*, which, however, he does not quote.

Recorde's meritorious labours, like those of the greatest benefactors of our species, seem to have been ill requited, since, having removed to the metropolis, he died under confinement for debt, in the Fleet prison. He evidently alludes to this, at the close of his above-mentioned work:—

"*Master*.—But harke! what meaneth that hastie knockying at the doore?

"*Scholar*.—It is a messenger.

"*Master*.—What is the message? tell me in mine eare.——— Yea, sir, is that the matter? Then is there noe remedie, but that I must neglect all studies, and teaching, for to withstande those daungers. My fortune is not so good, to have quiete tyme to teache."

Recorde was, before this, teacher of mathematics at Cambridge; he also styles himself "practitioner in physic;" he died in 1558.

Thus much for English science during the middle ages; slow progress was made; almost everything was received from abroad, and little was returned. To avoid repetition, and repeating what the reader may find in every biographical dictionary, I have omitted by far the most interesting character—Roger Bacon. The rest have been so completely overlooked, that that alone would afford a sufficient pretext to sketch an outline of their labours.

Of trifling import as the discoveries of the English in science during the middle ages may be, yet, when viewed in comparison with the labours of our continental neighbours on the same subject, we have no reason to complain. The works of Roger Bacon alone, would more than counterbalance all theirs, during that time, and if the others made no new discoveries, yet their names deserve to descend to posterity for contributing to preserve the sacred flame of science, at a period when every succeeding year increased the probability of its being extinguished.

A list of the discoveries of the English prior to 1600, I here annex, in which, as I have no doubt, many are omitted:—

1. The air-pump, by Roger Bacon.
2. The camera-obscura, by R. B.
3. The reformation of the calendar, by R. B.
4. Gunpowder, by R. B.
5. The diving-bell, by R. B.
6. The log, by Humphrey Cole.
7. Paddle-wheels, by Bourne.
8. The inclination of the needle, by Robert Norman.
9. The extraction of the roots of compound algebraic quantities, by Robert Recorde.
10. The sign of equality, by R. R.
11. Telescopes.
12. The true method of dividing the meridian line, by Edward Wright.
13. The true method of constructing the charts usually attributed to Mercator, by E. W.
14. The method of dividing the quadrant by diagonals, by Richard Chancellor.

It must not be forgotten, that there are several also to whom we are indebted for various improvements in the different departments of science: for instance, William Bourne, in his *Regiment for the Sea*, by considering the irregularities in the moon's motion, shows the errors of the sailors in finding her age by the epact, and also in determining the hour from observing on what point of the compass the sun and moon appeared.

With respect to the telescope, the claim of the English to its invention has been satisfactorily demonstrated by Barlow, in the *Encyc. Metrop.*; to the authorities which he brings forward, I may add, that William Bourne, in his *Inventions or Devises*, describes the instrument at full length in his hundred and tenth device; the original inventor is not known.

Among the manuscripts in the British Museum, (Sloane, 3651,) is one by William Bourne, which is unpublished; it is dedicated to Lord Burleigh, and consists of directions for gunners, land surveying, and the mensuration of heights and distances; it thus concludes:—

> Yt hath bynne seene and knowne, yat knolledge dyd availle,
> Boot now in this day money doth prevaille:
> Yet, in the eande, if you marck yt well ye worlld ys so frayll,
> That knowledge shall prosper when yat money shall fayle.

There is nothing of peculiar interest about the volume, which appears to have been written prior to any of his published works; it is evidently intended for the press. J. L.

ECONOMICAL USES OF SOME SPECIES OF TESTACEA.

(Concluded from page 48.)

VI. MUREX ———? (Linn.)—Hebrew *Argaman*. Greek *Πορφύρα*. Latin *Purpura*. *Purple Whelk*.

WHAT the species was from which the ancients obtained the real Tyrian dye, is now uncertain, but in colouring cloth there is no doubt that many species, and perhaps two or three genera, were used. The *Murices*, the *Buccina*, and the *Strombi*, and probably most of the voluted univalves, contain more or less of the colouring matter, and we may reasonably suppose that they would not be neglected where there was so great a demand for the purple dye. By the old writers, however, they are all described under one name. Pliny makes mention of two species, from one of which only the true colour was obtained; the other (which he calls *Conchylium*,) seems, from his description, to have been a real Buccinum, and produced only a poor blue or greenish hue, like the sea in a storm, while it emitted a strong rank smell, and was of course less valuable. The shell dye has been in use from the earliest periods. Moses, B. C. 1491, makes mention of it in several places, and he used much wool of a purple colour in the works of the tabernacle, and in the garments of the high priest[*]. This the Israelites must have brought out from Egypt, with them, and from the quantity in their possession, it cannot have been very scarce in that country. It was used as royal robes by the kings of Midian, B. C. 1249[†]; and B. C. 606, the Babylonians covered their idols with garments of purple[‡]. At the same time it was also the royal colour among these people, and we find that Daniel, after explaining the writing on the wall, as a special mark of favour, was clothed in it[§]. Alexander Balas, king of Syria, sent Jonathan Maccabæus a crown of gold, and a purple robe, allowing him to take the title of king's friend[||]. The band or Cydaris, which formed the essential part in the old Persian diadem, was composed of a twined substance of purple and white; and anybody below the royal dignity presuming to wear these colours, unsanctioned by the king, was guilty of a transgression of the law deemed equal to high-treason[¶].

Although in after times it was almost exclusively known by the name of Tyrian purple, yet it appears to have been only on the decline of that great commercial city that it was manufactured there. It is mentioned by Ezekiel[**] B. C. 588, as being imported from the Isles of Elisha (Peloponnesus) and Aristotle[††], as late as B. C. 340, makes no mention of its being brought from Phœnicia. In his time the best and largest shells were from Sigæum and Lectum on the promontory of Troas, and the smaller and inferior from Euripus and Caria. When, however, Tyre had lost its commerce, and become an inferior place, the chief supply of Europe was drawn from it, though we find it imported into Rome from Lacedæmon, and manufactures of it in various parts of Italy as late as A. D. 14*. During the earlier periods of the Roman republic it was solely worn by the kings and patricians, but in later times Pliny† informs us that cloth of this colour was so common as to be employed as tapestry, and for the covering of furniture, by all the better class of citizens. He also remarks, that so great was its antiquity, that the introduction of it was unknown to him, and adds from the chronicles then extant, that Romulus and his successors used it,—which was perhaps only the same as saying that the first invention of it could not be traced. The Grecian tradition, but which of course was merely a fable, was that Hercules Tyrius was the first discoverer of it, his dog by chance having eaten the shell fish, and returned to him with its lips tinged with the purple colour. Da Costa imagines that the dyeing qualities of the periwinkle (*Buccinum Lapillus*, Linn.) were known to the ancient British, and quotes the authority of the venerable Bede, who lived (on the sea coast) in the early part of the eighth century‡.

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[*] Exodus xxv. 14. xxviii. 5—6. *Josephus, Ant. Jud.* lib. iii. c. vii. § 7.

[†] Judges viii. 26.

[‡] Jeremiah x. 9. Baruch vi. 12.

[§] Daniel v. 7.

[||] Maccabees i. 20. These references are from *Calmet's Dictionary*, Art. PURPLE, where they are distinctly understood to refer to the dye from the shell.

[¶] *Sir Robert Ker Porter's Travels in Georgia*, quoted in *Horne's Introd. to the Holy Scriptures.*

[**] Ezekiel xvii. 7.

[††] *Aristot. de Hist. Animal.* lib. v. cap. 15.

Among the Greeks, Lycurgus ordered the Lacedæmonians to clothe their soldiers with scarlet, [*purple*,] the reason of which institution seems either to have been because this colour is soonest imbibed by cloth, and most lasting and durable, or on the account of its brightness and splendour, which the lawgiver thought conducive to raise the men's spirits, or lastly, because it was most proper to conceal the stains of blood. In war, a purple garment was frequently placed on the end of a spear, and used as a flag or signal§.

And though Jesus Christ was clothed in purple before his crucifixion, as a mark of derision, yet at this time it does not appear to have been either universally or necessarily worn by princes. Herod, when giving audience to the ambassadors from Tyre and Sidon, is described as being dressed in "*royal apparel*," which was not purple, but, as Josephus tells us, was wholly of silver‖.

The shells inhabit all the shores of the Mediterranean, but the best were procured at Tyre, the island of Meninx, the coasts of Gætulia and

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* *Macpherson's Annals of Commerce. Juvenal, Sat.* viii. 101.

† *Plin. Hist. Nat.* lib. ix. cap. 36. lib. xxxi. cap. 10. from which all the information with respect to the Romans is drawn, where not otherwise pointed out.

‡ "*Sunt cochleæ, satis superabundantes, quibus tinctura coccinei coloris conficitur; cujus rubor pulcherrimus nullo unquam solis ardore, nulla valet pluviarum injuria pallescere, sed quo vetustior, eo solet esse venustior.*" Bede, Hist. Eccles. lib. i. cap. i. See *Donovan's British Shells*, in loco *B. Lapillus.* It is to be remarked that Bede lived at Jarrow, about five miles from the mouth of the river Tyne, which there divides the counties of Durham and Northumberland, and the rocks on that coast at the present day abound with this shell: indeed, so plentiful are they, that it may almost be said that acres of rocks are hidden from sight by the clustering of the fish, intermixed with the *Balanas elongatus*, (Mont.) and young of the *Mytilus edulis*, and the supply is quite sufficient to have served for an extensive manufacture of the dye.

§ *Potter's Archæogia Græca.*

‖ Ενδυσαμενος 'εσθητα βασιλικην. Acts xii. 21. Στολην 'ενδυσαμενος εξ αργυρου πεποιημενην ΠΑΣΑΝ. *Josephus Ant. Jud.* lib. xviii. c. 8. § 2.

Laconia, and the island of Coa in the Ægean Sea[*]. The real Murex was fished for and caught with small and delicate nets; a bait was put in them, consisting of cockles or other bivalves, which had been so long kept out of water, that on being thrown in again they gaped widely. The Murex attacked them as food, and was drawn up with them. The other species were found adhering to rocks, on mud-banks, &c. The season for catching them was in the spring, when the dye was the deepest and best. It is contained in a small white vein, which lies in the neck of the fish, and in its natural state is a thin and almost colourless liquor. The shell was carefully broken off, and as the dye loses its value when the fish is dead, they were obliged to cut it out alive. The veins were then laid in salt, and left to settle for three days; after which the whole was boiled for ten days more, and the fleshy parts skimmed off as they rose to the surface, till the whole liquid was clear, bright, and red. The longer it was boiled, the deeper of course the colour became. After this, the wool, well scoured, was steeped in it for some hours, then cleaned and carded, and put in again, to remain till it could absorb no more. Nitre was employed in fixing the colour. The hue of the Tyrian dye was of a very deep red, soft and shining; the colour of a rose, but approaching to black, or like a very deep shade of the colour now called *lake;* of course the word *purple*, as at present understood, conveys a wrong impression. When the smaller and inferior species were used, the process was the same, with the exception of their being crushed in the shell, instead of the vein being cut from them. The two were occasionally mixed to produce a variety of shade, according to the fashion[†]. No mention is made of linen being so dyed, and it seems to have been confined to woollen fabrics, and perhaps, as some think, to cotton. A writer in the *Philosophical Transactions of the Royal Society of London*[‡], anno 1684, mentions a person at Minehead, on the Bristol Channel, who made it his business to mark linen with the liquor from shells. From the description and plate given, he appears to have made use of the common periwinkle (*Buccinum Lapillus*, Linn.) for this purpose. On trying the experiment himself, the writer found the colour to vary much, and frequently before attaining its final hue. At first it was pellucid and nearly colourless, then became a light green, and if placed in the sun, immediately much darker; in a few minutes it changed to a full sea green, and after that into a watchet blue; in a few minutes more it was a purplish red, and after lying an hour or two became a very deep purple. Further than this the sun did not affect it, but on being washed in soap and water it changed to a very bright and brilliant crimson. When the article dyed with it lay in the sun, it emitted a very strong and fœtid smell, as if garlic and assafœtida were mixed together. More lately a species of shell was used by the Spanish Americans at Nicoya, also for dyeing with, but the cloth thus prepared was so expensive as only to be worn by the nobles[*]. Among the Romans the royal edicts were frequently signed with this liquor, and it was used as a pigment by artists.

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[*] *Plin. Hist. Nat.* and *Juvenal Sat.* ut supra.

[†] This appears to be the *dibaphos* and *bistinctus* of the Latin writers, and which does not imply that the wool had been twice dyed in the same liquor to produce a deeper shade, as some suppose, but that it was of an entirely different hue. Pliny says such was the most fashionable and most expensive.

[‡] *Trans. of the Royal Society, abridged*, vol. ii.

In common with the rest of the genus, the fish is carnivorous and locomotive, living sometimes in deep water, and sometimes burying itself in the shore, while it is constantly searching for food. The colouring liquor is probably provided as a means of defence to the animal, as the ink of the cuttle-fish, or the saliva of the snail; and although we have never observed the fact in any American or British species, the fish when touched is said to have the power of voluntarily emitting it[†]; in which case it comes out purple, and of a very rank and offensive odour. If this be so, it must undergo some change in passing through the vein, as when cut out it is white, and long in attaining its purple and final hue. Since the discovery of America, and the introduction of cochineal into Europe, the fish dye has been entirely neglected as an article of merchandise, and is not, that we are aware of, anywhere used in the present day.

VII. Murex Tritonis, (Linn.)—*Trumpet Shell.*

This fine univalve is indigenous to most warm climates; it inhabits the African, American, and Asiatic seas, and is found on the coasts of the islands of the Southern Pacific. The only use it appears to be put to, is the making of musical horns or trumpets of it, and for this purpose it has long been used by the natives of Africa and India, and even long before the Christian era it was thus employed by the inhabitants of the countries bordering on the Mediterranean. By the ancient Greeks it was universally used for giving signals in war. On the discovery of the Society Islands, it was found to be used in war, by the native priests on solemn occasions, and by the heralds in their ships; it was, in fact, the royal and religious instrument of music, and only made use of as such. The largest shells were selected for the purpose, which in general are about one foot in length. They made a perforation about an inch in diameter, near the apex, and into this they inserted a bamboo cane about three feet in length, which was secured by binding it to the shell by fine cocoa-nut braid. The whole was made air-tight with the gum of the bread-fruit tree. The sound is described as being extremely loud, but the most dismal and monotonous that it is possible to imagine. As late as the last century it was used on board of ships trading to the West Indies or South America instead of a speaking trumpet. A species was also used (and perhaps still is) in Barbadoes, but whether the present one, we cannot, from the description, determine; it served instead of a bell to call the slaves to their work, and sounded so loud, that on a calm morning it might be heard above a mile off. The apex was merely broken, and then blown through. The fish was eaten, and divers were regularly employed in catching it. They were generally met with in about six fathoms water, but after heavy rains they were found at the mouths of the water-courses, feeding on the garbage washed down to them. If the water was dimpled so that the bottom could not be seen, the divers poured a spoonful of oil on the surface, which calmed it sufficiently for their purpose. When the tail part, which was somewhat gritty and sandy, was taken away, the rest of the fish tasted like "tripe, but shorter, sweeter, and more luscious." It is this shell which is generally represented in the hands of Triton in pictures, and whence its trivial name[*]; and from the use to which shells were thus put, originated the word *Buccinum*, which, among the ancients, included at least a third of the known univalves[†].

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[*] *Rees' Cyclopædia.* Art. Purple Fish.

[†] *Aristot. de Hist. Animal.* lib. v. cap. 15. *Hughes' Nat. Hist. of Barbadoes.*

VIII. Murex ——?

Another species of Murex (?) was used by the Greeks in preparing a pigment for painters; but the colour was obtained from the outside of the shell, and not from the fish, as was the purple dye[‡].

IX. Ostrea edulis, (Linn.)—*European Oyster*.

Ancient History.—The oyster has probably been used from the earliest periods. As they lie in comparatively shallow water, quickly increase in numbers and size, and offer a very nutritious and refreshing food, we may reasonably suppose that the aborigines of those countries where they are found, were in general well acquainted with them. From Aristotle we learn that the Greeks in his time ate them[§]. It was as early as A.U.C. 633, that the mode of fattening them by laying them in pits and ponds was introduced to Rome. At that time, one Sergius Orata first tried the experiment on the Lucrine oysters, and as he made much money by it and his plan succeeded well, it rapidly spread into different districts. As Rome increased in luxury, the supply from the immediate coasts was not sufficient, and all the shores of the Mediterranean were ransacked for the shell-fish. They were frequently brought from a great distance, and at much expense, to be fattened in Italy for the Roman feasts. They abounded at Abydos on the Hellespont[||]; but the most celebrated appear to have been procured at Circæum, the Lacus Lucrinus, and from Brundusium. Much, however, of the fame of these places appears to have arisen from fashion, as we find writers of different times praising as the best those from different districts. The most generally esteemed, however, seem to be those from Rutupiæ, (now Sandwich, in Kent, England,) and which were carried to Italy in great numbers. If we consider the difficulties of land carriage, and the slowness of sailing vessels in those times, we may form some idea of their price, and the height to which luxury in eating had attained. In later times they appear to have been chiefly used for supper*. That many different species were used is probable. Pliny informs us that those from Circæum (Capo Cieceji) were black both in the flesh and shell, those from Spain reddish, and those from Sclavonia brown and dusky†. It was supposed that the fish fattened during the full moon, and grew thin as it waned; we are not aware that this has been observed in the present day, but it may have happened in particular situations, owing to the difference in the tides. The Roman epicures were in the habit of iceing them before eating them, and the ladies used the calcined shell as a cosmetic and depilatory. To the doctors this fish was most valuable, being recommended in a great variety of diseases, and prepared in various ways; and though it could, generally speaking, do no good, it certainly could do little harm.

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[*] Thus Ovid, speaking of Neptune—

—"supraque profundum
Extantem, atque humeros innato murice tectum
Cœruleum Tritona vocat, conchæque sonaci
Inspirare jubet, fluctusque et flumina signo
Jam revocare dato, cava buccina sumitur illi
Tortalis in latum quæ turbine crescit ab imo."
Ovid. Metamorph. lib. i.

[†] *Dillwyn's Des. Cat.* vol. ii. p. 727. *Plin. Hist. Nat.* lib. xxxii. cap. ii. *Ellis' Polynesian Researches*, where a wood-cut of the instrument is given. *Hughes' Nat. Hist. of Barbadoes.* *Potter's Archæologia Græca*, where there is given a long dissertation on the time in which real trumpets were introduced instead of the shells.

[‡] "Concha quæ pictoribus usui est crassitudine plurimum excedit, at florem illum non intra tectem, sed foris habet." *Arist. de Hist. Anim.* lib. v. cap. 15. *Interpr. Du Val*, tom. ii. p. 844.

[§] *Aristot. de Hist. Animal.* lib. v. cap. 15.

[||] *Virgil. Georg.* i. 207.

Modern History.—In England, the oyster fisheries are chiefly carried on at Colchester, in Essex, celebrated for its *green* oysters; at Feversham and Milton in Kent, and in the Isle of Wight. They are also fished for in the Swales of the Medway, at Tenby on the coast of Wales, and near Liverpool, as well as around Portsmouth, and in many of the creeks of the southern coast. The best are found at Purfleet, the worst near Liverpool. They are very plentifully but partially distributed, and are found to extend further north on the western than on the eastern side of the island. In Scotland they also abound, but appear likewise to prefer the north-eastern to the north-western coast. While they are every where plentiful and highly flavoured, from the Clyde to the Zetland, Orkney, and Western Islands, it does not appear that they breed higher on the other side than the Firth of Forth. Those on the western shores are, however, comparatively little used, and, with the exception of a few sent from Loch Tarbert to Greenock, they are consumed by the natives on the spot. Those of the eastern coast, on the contrary, are carried to Newcastle-upon-Tyne, Hull, and London, and have been exported in large quantities to Holland. The best are procured near Preston Pans, Port Seaton, and the Isle of Inchkeith, in Musselburgh bay, Firth of Forth; and vessels from Milton, Lee, and other parts of England, come to dredge for them, and carrying them away, afterwards fatten them for the English markets. Those from Preston Pans are known by the name of *Pandoors*, as being found at the door of, or near the pans, and from the quantity of fresh water are the fattest and best flavoured. In Wales, Milford Haven is celebrated for its oysters.

Oysters are found on most parts of the French coast, but they are most plentiful on those of Bretagne and Normandy. The most extensive fishery is that which is carried on at Granville, in the bay of which, and for six leagues to the northward, they abound. The fishermen bring them to the town and dispose of them to women, who after having fattened them, dispose of them, either pickled or in the shell. Paris, Dieppe, and Rouen, are chiefly supplied from this place, for which purpose boats are continually arriving from other parts. The oysters from Rochelle and Bordeaux, and generally from the coast of Bretagne, are however by far the most esteemed; being fatter and more highly flavoured, owing to the quantity of fresh water there running into the ocean. Here they are *greened* in the same manner as in England, and require about the same time to come to perfection. They are all to be met with in Paris, but those from Normandy in the greatest numbers. The appetite for shell-fish of all sorts, which seems peculiar to the natives of the southern provinces of Italy, is such as to appear exaggerated to a foreigner, accustomed to consider but a few of them as eatable. So great, however, is it, that at Taranto, the government draws a revenue of twenty-four thousand ducats annually from the shell fishery alone. In the Mare Piccolo, on which this place is situated, the spawn of the oyster is received on large conical earthen pans, secured at equal distances by ropes tied to them, and sunk in different parts of the bay. Their appearance is equally singular and beautiful; the vessel becomes entirely hidden by the shells, when the whole assumes the form of one solid but irregular mass of rockwork. The young oysters being rubbed off, are scattered through various parts of the bay, and finally, when sufficiently grown, are collected by means of iron rakes.

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* *Juvenal, Sat.* vi. 301.

† *Plin.* Hist. Nat. lib. ix. cap. 32.

Of the quantity of oysters consumed in England, we have no certain or continuous statistics. In 1824, the quantity bred and taken in the county of Essex, and consumed mostly in London, was supposed to amount to fourteen thousand or fifteen thousand bushels. They are at times imported in considerable numbers, but the yearly quantity is subject to important fluctuations. In the season of 1801-2, one hundred and eighty-eight British vessels, carrying from six to nine men each, were entered at the custom house of Cancale, in France, and carried back one hundred and nineteen millions four hundred and seventy-three oysters, chiefly to London. On an average of 1831—1832, the imports into the same city amounted to fifty-two thousand and ninety-five bushels a year. In or about 1786, Glasgow consumed twenty thousand annually, which were carried from Leith on horseback or by carts, across the country. The quantity in the present day must be much greater. In 1803 the consumption of Paris was estimated at one million dozen, selling on an average at six sous per dozen.

Natural Habits.—The European oyster is smaller, thinner, and more rounded than the American, while the lower valve is less concave or vaulted; it is not beaked, and the fish, compared with the size of the shell, is smaller and of a different flavour; there are, besides, various other differences, and their habits are so very dissimilar that there can be no doubt at all of their being distinct species. The European oyster is found only adhering to rocks and stones, or occasionally to very strong clayey bottoms, and should these be washed away, the oyster beds perish. The fish is viviparous, and the young produced with a perfectly formed shell. They are, when first emitted, quite transparent, and they swim with great quickness, by means of a membrane extending out of the shell. So small are they in this state, that Van Leeuwenhoek computes that one hundred and twenty of them in a row would extend an inch, and consequently a globular body, whose diameter is an inch, would, if *they were round*, be equal in size to one million seven hundred and *twenty eight thousand* of them! The vulgar opinion, and that on which the restraining laws have been framed is, that the period of spawning is May, at which time the young, or *spat*, is found adhering to the rocks. But as the young, as described above, are found in the parents perfectly formed and alive in the month of August, this is most probably the period of parturition, though it be not till May that they become fixed or sufficiently grown to be seen by the common observer. At this time they are about the size of a sixpence, and comparatively hard and firm, and have been well compared to a drop of candle-grease in water. In two, or at farthest three years, they are fit for the table. The age to which it attains is probably great, but after having arrived at its full size, the valves are thickened, instead of being increased in length or breadth. From May to July, both the male and female oyster are said to be *sick*, and are in thin and poor condition, but by the end of August they have again recovered, are fat and in season. The sexes are distinguished by the fishermen, by the colour of the fringe, that of the male being black, or dark coloured, that of the female white. Sand is prejudicial to them, a mixture of fresh water advantageous. The shell, according to Mr. Hatchett, is formed of carbonate of lime and a great proportion of animal gluten, but more intimately mixed, and not lying in regular layers, as in the perlaceous shells*. The oyster frequently contains shining intestinal worms, or animalcules, which may be seen by opening the shell in the dark. A most destructive animal in an oyster-bed is the sea-star, (*Asterias glacialis*, Linn.) which clasps its rays round the shell and perseveres till it has sucked out the inhabitant. Another enemy is said to be the muscle (*Mytilus edulis*, Linn.)

Fishery.—In both England and France the season for fishing for the oyster is restricted by law. In the former country the time allowed for collecting the spawn from the sea is May, when the dredgers may take all they can procure, but after that month they are liable to be convicted of felony if they disturb it, and are only allowed to take such oysters as are the size of half a dollar. The spawn, or *spat*, as it is technically called, is dredged up, and if not too small, they separate it from the shells and stones to which it is adhering, and these they are obliged again to throw into the water to prevent the beds being destroyed. The spat is thrown into creeks or into shallow water on the shores, to increase in size and fatten, and in such situations is considered private property. At Preston Pans the oysters are not *bedded*, but are entirely procured from the sea, and in dredging, those which are too small are thrown back again. The season begins on the first of September, and lasts till April. The dredgers make use of a peculiar kind of net, which is very strong, and fastened to three spikes of iron; this they drag along the bottom of the sea, and thus force the oysters into it; each boat requires five men, and they dredge in water from four to fifteen fathoms deep. The *green* oysters are all procured at or in the neighbourhood of Colchester. When they wish to give them this colour, they throw them into pits dug about three feet deep in the salt marshes, which are overflooded only at spring tides, and to which they have sluices to let out the salt water till it be about one and a half feet deep. These pits become green, and communicate their colour to the fish in four or five days, although they commonly let them continue there six weeks or two months, in which time they will become a dark green. The colour has recently been ascertained to arise from confervæ, and other marine vegetable matter, decayed by the heat of the sun, on which the animal feeds. A very common and very mistaken opinion exists, especially among foreigners, that not only those, but all English oysters, are impregnated with copper, "*which they get from feeding off copper banks;*" such we believe would be quite as injurious to the animal itself as it could be to us, and the fancy can only have arisen from the strong flavour peculiar to this fish. Green oysters are comparatively little esteemed in the present day.

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* Professor Rogers doubts the accuracy of this analysis, as regards the quantity of animal matter contained in this shell, and he supposes that there only exists a very minute portion of gluten. In this opinion he states that he is supported by the experiments of Bucholtz and Brandes, and those he himself made on the *Ostrea Virginica*. What the shells were which were used by the former gentleman, we are not informed; but with all deference we would suggest that he himself seems to have forgotten that the American and British shells are quite distinct species, from which *most probably arises* the difference he has discovered, and which, instead of proving Mr. Hatchett's experiments to be in the main incorrect, only tends to prove that the species are perfectly distinct, and not mere varieties. The quantity of gluten contained in the *Ostrea edulis*, is well known to even the most superficial observer, where the shell is common, and may be found in the large and thick specimens, or on the decaying of the shell, between the inner and outer laminæ, frequently in great quantities. It is of a dirty yellow colour, and thick and clammy in its consistency. See *Silliman's Am. Jour.*, vol. xxvi. p. 361.

Use.—The great value of this animal is for diet. The shell was at one time supposed to possess peculiar medicinal properties, but analysis has shown that the only advantage animal carbonates have over those of the mineral kingdom, arises from their containing no metallic or foreign substance[*]. The inhabitants of the shores of Hindoostan did, two centuries since, and perhaps still may, use it in the same manner. The fish is recommended by the doctors where great nourishment and easy digestion are required, the valuable quality being the quantity of gluten it contains. In the north-eastern parts of England, old houses may be seen with their tops and gable ends ornamented with these shells, only the inside being exposed; a custom which is said, we know not with what truth, to have been introduced from Holland. In some parts of Scotland the shells are used as manure, and found very excellent and stimulating; in other places they are burned as lime.

In 1768, Mr. John Canton discovered that a very good phosphorus[†] could be made from oyster shells. He added a little sulphur to them, and by calcination produced the substance. A long account of the process and his experiments is given in the Philosophical Transactions of that year. The French have a proverb drawn from this animal, which they apply to an awkward person, "*Il parle ou joue, &c. comme un huître à l'écaille*[‡]."

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[*] Iodine is found in some of them.

[†] So called from its emitting light in the dark, after exposure to the sun's rays.

[‡] In compiling this article, the following works are those which have chiefly been referred to and quoted from:—*Plin. Hist. Nat.* lib. xxxii. cap. 6., lib. ix. cap. 36. *Rees' Cyclopædia*, Art. Oyster. *M'Culloch's Comm. Dict.*, Art. Oyster. *Brewster's Edinburgh Encyclop.*, Art. Fisheries. *Encyclop. Americana*, Appendix, Art. Oyster. *Postlethwaite's Dict.*, Art. Oyster. *Sinclair's Stat. Hist. of Scotland. Keppel Craven's Tour. Statistique générale, &c.* par P. E. Herbin. *Diction. de Trevoux. Philosophical Transactions.*

Besides these, oysters are found in most countries; the following are a few of the species.

The West Indies have, according to Hughes, two oysters, a large one, in deep water, which is seldom eaten, and the mangrove oyster, which adheres to the roots of the trees in the wash of the tide, whence the old fable of oysters growing on trees. The same are found in Sumatra, where we are told that they are by no means so good as those of Europe*. Round the shores of New South Wales, oysters are extremely plentiful, and though generally small, are of delicate flavour. Every rock is covered with them, and Mr. Martin informs us he has seen parties of young ladies, with small hammers, seated on a large rock, and feasting with great *goût* on these dainties†. In Southern Africa, the oysters of Mossel Bay are much celebrated, and their flavour considered so fine, that epicures have been induced to visit the bay from Cape Town, (Cape of Good Hope,) for the express purpose of enjoying a feast of them. The distance is about three hundred miles, so that they ought to be good to repay the trouble‡.

X. OSTREA SCABRA, (Linn.)—*Scaly Oyster.*

This is an inhabitant of the Bahama islands, where it is eaten. It is occasionally to be met with in the Philadelphia markets, for the same purpose.

XI. MYA PICTORUM, (Linn.)—*Painters' Gaper,*

Is common to many of the rivers of Great Britain, and the north of Europe. It was formerly made use of for holding the colours employed by artists, whence its trivial name; but for the last thirty or forty years it has, we believe, been entirely neglected for this purpose, and is now only to be met with in collections.

XII. TURBO LITTOREUS, (Linn.)—*Whelk.*

This shell is common to most of the shores of Great Britain, but is perhaps most plentiful on the limestone rocks, on the north-eastern coast of England, where it lives in common with the periwinkle, below high-water mark: it is gathered by children and old men, and retailed, boiled in small measures, in the streets of the seaport-towns. They are never very abundant, and may be considered rather as an humble luxury than an article of food.

The periwinkle, (*Buccinum Lapillus*, Linn.) though so nearly resembling it, and more common, is not, that we are aware of, ever used in the present day, though it formerly was, as Holinshed tells us: "We have, in like manner, no small store of great whelkes and perewinkles, and each of them brought farre into the land, from the sea coaste, in their severall seasons§."

XIII. PECTEN MAXIMUM, (Penn.)—*Great Scallop.*

This shell is found on most of the coasts of Great Britain and Ireland, particularly on those of Portland and Purbeck, in Dorsetshire, and near

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* *Marsden's Hist. Sumatra.*

† *Martin's Hist. of the Br. Col.*

‡ Webster's Voyage to the S. Atlantic Ocean, 1830.

§ Holinshed's Chronicles.

Yarmouth, in Norfolk. The fish is eaten, and in some parts it is pickled and barreled, and in this state is the object of a small commerce. Holinshed mentions them as being extensively used in Henry VIII. and Queen Elizabeth's reigns, and they are still cooked in various ways, and considered a luxury. The fish was formerly supposed to be medicinal, and recommended by the doctors as "detersive, aperitive, and carminative," and the shell was also administered in the same manner as that of the oyster. At a still earlier period it was worn by pilgrims, and thence found its way into armorial bearings*. It was, however, properly speaking, peculiar to the Compostella pilgrimage. Popes Alexander III., Gregory IX., and Clement V., granted in their bulls a faculty to the archbishops of Compostella, that they might excommunicate those who sold these shells to pilgrims any where except in the city of Santiago; and the reason assigned is, that the scallop shell is the badge of the apostle of Santiago, or St. James†. They were occasionally carved as cameos. The shell lies in large beds, in moderately deep water, and is procured by dredging. In common with the other species, they are locomotive, and have the power of springing or leaping, by which they move themselves. They effect this, by suddenly forcing the under valve against whatever they lie on, and so raise themselves a few inches at a time. The only value which the shell has now, is for its occasional, but well known use, as a substitute for a dish‡.

XIV. Pecten Opercularis, (Penn.)—*Small Scallop.*

This shell, though smaller and less common than the former, is occasionally used as food on the southern coasts of England. Its habits are the same as the last, and the shell is not put to any use§.

XV. Pecten Concentricum, *American Scallop,*

Is found along the whole coast of the United States, from Maine to Florida. It does not appear to be very generally used as food, but is occasionally to be met with in the New York markets and oyster cellars, for that purpose.

Of this genus many more species are most probably used as food in different countries, as, when large enough, they are always easily obtained, wholesome and palatable.

XVI. Voluta Gravis, (Linn.)—*Chank.*

These shells form a considerable article of trade in Hindoostan, where they are in extensive demand all over the country. They are sawed into narrow rings, and are worn as ornaments for the arms, legs, and fingers, by the Hindoo women. Many of them are likewise buried with the bodies of rich and distinguished persons. They are fished up by the pearl divers in the Gulf of Manaar, and elsewhere in India, in about two fathoms water. The fishery is monopolized by government, who most commonly let the banks for as much as four thousand pounds sterling, per annum, but the trade is free. When the Dutch held possession of Ceylon, the fishery was open to all, but the trade to Bengal was a monopoly in the hands of the Company. A chank, opening to the right, called in Calcutta the *right-handed chank*, is so highly prized, as sometimes to sell for four hundred five hundred, or even one thousand rupees, or about five hundred dollars, American currency*.

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* "The scallop shows in a coat of arms,
That of the bearer's line,
Some one in former days hath been
To Santiago's shrine."
Southey's Pilgrim. Introd.

† *Southey's Pilgrim. to Compostella, Notes, where various traditions of the origin are given.*

‡ *Donovan's Br. Shells*, pl. 49. *Holinshed's Chron.*, and *James's Medical Dictionary*, Art. Pecten.

§ *Murray's Encyclopædia of Geography*, Art. England. Transactions of the Linnæan Society of London, Vol. viii.

XVII. Cyprea Moneta, (Linn.)—*Money Cowry.* Hindoostanee, *Kapardakas*—Guinea Coast, *Timbis.*

This little shell is indigenous both to the East Indies and the western coast of Africa. In the former, they are chiefly found on the shores of the Laccadive and Maldive islands, and are thence imported into Calcutta and Bombay. In both continents they are used as a circulating medium, and in India they pass current in the British presidencies, but for very low values. In Calcutta two thousand five hundred and sixty cowries are worth one current rupee, or about fifty cents; but there are several intermediate and nominal coins, the lowest worth four of these shells. They are, however, quickly disappearing from commercial transactions, where Europeans are settled. Previous to the abolition of the slave trade, they were largely imported into England, to be subsequently used in Africa, and though the quantity is much diminished, they are still to be found in the price currents of London and Liverpool. In Peale's Museum at Philadelphia, there is a singular head-dress of scarlet cloth, entirely studded with these shells, which is said to have been brought from China†.

XVIII. Chiton Fasciatus? (Linn.)—*Beef Shell.*

The only instance, we believe, of any species of this genus being used, is the present, at the island of Barbadoes, where they are cooked for the table. We are told that the fish is of a pale red colour, (whence its provincial name,) and that "it is very firm eating, short, and well tasted." It is about one and a half inches in length, and three quarters of an inch in breadth. It appears to be abundant, and living on the rocks, is easily obtained. The shell is useless‡.

XIX. Murex Despectus, (Linn.)—*Rock Whelk.*

This, the largest of the British univalves, is not uncommon on most of the coasts of Great Britain. It is occasionally drawn up with oysters, but we have most frequently obtained it from the ground lines of the fishermen, to the baits of which it adheres. In common with the rest of the genus, it is carnivorous. It is occasionally eaten, but being coarse food, is more generally used as bait§.

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* *M'Culloch's Commercial Dictionary,* Art. Chank. *Diction. Univer. de la Géographie,* par J. Peuchet, Art. Ceylon.

† *M'Culloch's Commercial Dictionary,* Art. Cowries and Calcutta. *Martin's History of the British Colonies. Kelly's Universal Cambist.*

‡ *Hughes' Natural Hist. of Barbadoes.*

§ *Donovan's British Shells,* pl. 31.

XX. SOLEN SILIQUA, (Linn.)—*Razor Shell.*

THIS shell is found in abundance on many of the sandy shores of England, especially on the northern and western coasts, and on those of Scotland and Ireland. The ancients esteemed them, when cooked, as a delicious food, and Dr. Lister informs us that he thought it nearly as rich and palatable as the lobster. In England and Scotland, in the present day, it is more used as bait than for the table, but in Ireland it is still much eaten during Lent. It is in season during the spring, and the shell is of no value. It is eaten likewise by the inhabitants of the Crimea, bordering on the Black Sea, on the shores of which it is plentifully found[*].

XXI. The OPERCULUM of a species of shell is understood to have been used in making the sacred perfume of the Jews, the substance called in the Hebrew *specheleth*, and which in the English version is translated *onycha*[†], and by the Seventy, *onyx*. Dioscorides and Rumphius both describe the shell. It is found in the marshes of India, where the nard (*Andropogon nardus*, Linn.) grows, on the leaves of which it feeds, and is thence said to obtain its peculiar odour. The shells are gathered in the summer, when the heat has dried up the water; and it serves as the basis of all perfumes throughout the east. According to its etymology, (*ονυξ*) *onyx* signifies the nail of the finger or toe, which the substance resembles, and which, according to the Greek tradition, was so called from its being the parings of Venus' nails, cut off by Cupid with one of his arrows. The best was procured from the shores of the Red Sea, which was white and large: the Babylonian was black and smaller, and therefore, probably from a different species of shell[‡].

XXII. MYTILUS EDULIS. (Linn.)—*Edible Muscle.*

THIS shell is common to most parts of the world, being met with in each of the four continents, and, we believe, in Australasia. Specimens from different places certainly do differ, but so slightly, and so much the same are their habits, that a scientific naturalist finds it impossible to separate the species by any decisive mark.

In the warm climates they grow to a larger size, and their flesh is more nutritive, than in the cold. They lie in large beds, in shallow water, and adhere to each other or to foreign substances, by means of the byssus, which is particularly strong, but they are probably locomotive, at least when young. They succeed the best when always under water, but will also live on rocks only covered at high tide. They are generally used for the table, and make, perhaps, the best bait known for fishing. In England they are chiefly eaten by the poorer classes on the coasts, and seldom carried into the interior; in Lancashire, however, they have been planted in the river Wyre like oysters, where they grew fat and delicious. They are plentiful on most of the coasts of France, both in the Atlantic and Mediterranean, and are commonly used not only in the maritime departments, but also in Paris, and although they are seldom admitted to the tables of the higher classes, the consumption of them is very considerable. In the neighbourhood of Rochelle they are kept to fatten in salt water ponds, (*Bouchots*) into which a certain quantity of fresh water is allowed to enter; by which means they are improved both in size and flavour. They are in season in the autumn.

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[*] *Donovan's British Shells*, plate 46. *Histoire physique, morale, civile et politique de la Russie moderne*, par M. le Clerc.

[†] Exodus xxxi. 34. *Dictionnaire de Trevoux*, vol. iv., Art. ONYX.

[‡] *Calmet's Dictionary of the Holy Bible*, Art. ONYCHA. *Scripture illustrated by means of Natural Science.*

In Italy, where, owing to the frequent fasts, shell-fish enter more largely into the food of the people than elsewhere, this species is extremely plentiful. The sandy bed of the Mare Piccolo, on which stands the town of Taranto, is literally blackened by the muscles which cover it. The boats that glide over its surface are laden with them; they emboss the rocks which border the strand, and appear equally abundant on the shore, piled up in heaps, or packed in carts. They spawn on ropes, which are tied at intervals to poles stuck in the water, and these, when drawn out, exhibit the semblance of massive festoons of carved ebony, or brilliant black coral. When about the size of a small bean, they are plucked from the ropes, and scattered in different parts of the bay, whence, at the period of perfection, they are collected by means of iron rakes, and sent to market. They are generally to be met with in the New York markets, but the consumption is not large, neither is the fish so excellent as the European: they are common on the oyster-beds and other parts of the bay. The shell differs from the British species in being flatter, not so much ridged, more angular, more extended at the larger end, more polished on the outside, and it seldom grows so large or thick, but it is probably only a variety. Some parts of the fish (and at certain seasons all) are unwholesome, and there are instances where death has been caused by eating them: the shell was formerly in England occasionally used in a somewhat similar manner as that of *Mya Pictorum*, but otherwise it is of no value.

Where they abound, the European oyster is *said* to be destroyed by them, but this is not yet thoroughly proved. In Scotland, they are particularly plentiful on the western coast, and in some places are considered private property, and a revenue raised from them by making the fishermen pay a species of tax, or fixed rent for the quantity taken. They are enumerated by Holinshed among the shell-fish in use in his time, and are in the present day eaten by the inhabitants of the shores of the Black Sea[*].

XXIII. CARDIUM EDULE, (Linn.)—*Edible Cockle.*

THIS common English shell inhabits the low sandy and muddy shores of most parts of Great Britain, and is found a little above low-water mark. The specimens lie singly, about a foot deep in the sand, and like the *Mya arenaria* of this country, their locality is known by a dimple or depression, of about half an inch in diameter. They are dug out. They are likewise found on some of the French coasts, and in both countries are used for the table; but their consumption is entirely confined to the more humble and poorer classes. In the sixth century they, were, however, of much more importance, and eaten by all. In general they are prepared by simply boiling them, after having been kept a few days in fresh water to get rid of the sand they contain.

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[*] *Donovan's Br. Shells in loco. Hon. R. Keppel Craven's Tour through the Southern Provinces of Naples.* Sinclair's *Statist. Hist. of Scotland.* Herbin's *Statistique générale et particulière de la France*, &c. *Holinshed's Chronicles. Le* Clerc's Histoire de la Russie.

In the island of Barry, on the coast of Inverness, Scotland, this fish is at times the chief support of the inhabitants, and so plentiful are they there, that in seasons of scarcity the people have subsisted solely on them for months together. The popular opinion there is, that they spring from small animalculæ, brought down by the water springs from a certain green hill in the neighbourhood of the sands. Buchanan, the Scottish historian, gives a somewhat similar account of their origin, as being believed, in his time, throughout Scotland. Except the occasional burning of the shell as lime, or applying it as manure, it is of no value. They are in season during the spring*.

XXIV. Helix Pomatia, (Linn.)—*Edible Snail.*

Luxury perhaps attained to a greater height in ancient Rome than in any other country of which we have the history. Not only was there the most lavish splendour and magnificence in the houses and the temples; not only were these met with in the dress and equipages, but the most minute attention and refinement was applied to the science of cookery and to the table. The present shell is an instance of this: not content with eating animals as they were by nature, the greatest ingenuity was manifested in feeding and fattening them, and while Rome was mastering or holding in subjection one half the known world, thousands of birds were slaughtered to procure one dish of tongues, rivers turned from their course, and mountains cut through, to form oyster pits and lamprey stews, and patricians and senators thought it not beneath their dignity to superintend the minutiæ of snail warrens. This shell is indigenous to most parts of continental Europe, but it chiefly abounds in Italy and Spain. In the former it anciently was, and still is, much used for the table, and among the Roman epicures there was constant competition to prove who could produce the largest and the fattest. Pliny informs us that one Fulvius Harpinus was the first who invented a stew for snails, about B.C. 80, in which they were fed and protected. Every care was taken of them, and the owners of these warrens boasted as much of their snails, as gentlemen, in the present day, do of their horses. Several species, from various countries, were probably used, all of which were kept in separate departments, and were regularly fed on wheat-meal sodden with wine and mixed with a few laurel leaves. Thus preserved, they grew to a most surprising size, and, if we can believe the authorities, it was not uncommon for the shell, (naturally about two inches in diameter,) to contain ten quarts of liquid!

The *Cochlearia*, or snail stews, were generally made in open places surrounded by water, so that the snails might not abandon them, and care was taken that the places were not too much exposed to the sun or the dews. The artificial stews were most frequently made under rocks whose bottoms were watered by lakes or rivers, and if there was not a natural dew, they produced one by means of a pipe of water bored full of holes. They were also fed on a smaller scale, in large pots or pans, bored full of holes to let in the air, and lined with bran and wine-lees or vegetables. In Italy they are still fed in similar places on vegetables, and during Lent are eaten in great quantities. They are regularly exposed in the markets, as well as in those of Switzerland, Spain, and France, and are exported in barrels to the Antilles. They were introduced into England about two centuries since, and distributed through the counties of Surrey and Sussex, but by whom is now uncertain. They soon spread themselves, however, through most parts of the south, and are found at present in the country round Dublin. In the north they have never prospered, and we are not aware of any place more northerly than Northamptonshire, where they are to be found. In Holstein they are indigenous as far as the shores of the Baltic, and are the most common snail of that country; but neither there nor in England are they used for the table. In France they are the objects of a small commerce; the peasants collect them in the vineyards, and feed them till winter, when they seal themselves up, and in this state they are purchased by the confectioners, who prepare them in the shell with butter and herbs, and forward them to Paris. They are recommended in pulmonary complaints, and are used by the ladies as a cosmetic. The French have a proverb drawn from this shell, which they apply to an ill-formed or decrepit person—"*Il est fait comme une escargot.*" They are found in the Crimea, where they are eaten by the Tartars[*].

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* *Sinclair's Statistical Hist. of Scotland.* Holinshed's Chronicles.

The *Helix Aspersa*, (Muller,) was introduced into England by Sir Kenelm Digby, for the relief of those affected with diseases in the lungs, but is not, that we are aware of, now ever used.

XXV. UNIO ———?—*Fresh-water Muscles.*

THIS most abundant and interesting American family, though everywhere found, appears to be but little used. Some tribes of Indians eat them, and at present round one of the ponds at Plymouth, Mass., may be seen pits full of these shells, the fish of which had been consumed by the aborigines before the landing of the Pilgrims. Some of the thicker species of the Ohio, are said to have been at Pittsburgh successfully turned into buttons and ornaments resembling mother-of-pearl.

XXVI. CHAMA GIGAS, (Linn.)—*Boat Shell.*

THIS very fine and well-known bivalve is chiefly found in the Bay of Tappanuli, in Sumatra; but is sufficiently plentiful around New Guinea, and in other parts of the east; it lies in moderately deep water, and frequently grows to a very large size. One shell, described by Linnæus, weighed four hundred and eighty-nine English pounds, and he says the inhabitant has been known to furnish one hundred and twenty men with a day's food. Sir Joseph Banks had an account of one which weighed five hundred and seven pounds; the largest valve measured four feet six inches in length, and two feet five inches and a half in breadth, and one foot in depth. Large pearls are occasionally found in them; the same gentleman once exhibited one which was valued at between nine hundred and twelve hundred dollars; a large shell of this sort is used as a baptismal font in the church of St. Sulpice, at Paris, and was presented by the Venetians to Francis the First. The shell is worked by the natives of Sumatra into arm rings and other ornaments, and in the hands of their artists is found to take a polish equal to finest statuary marble. It is several inches thick, and perfectly white, and might probably be used to advantage in some of the finer arts in this country. One of the methods of taking them is by thrusting a long bamboo between the valves as they lie open, when by the immediate closure that follows, they are made fast. The name for this shell, in the language of Sumatra, is *Kima*, whence probably our word [*]. It is this shell in which Nepture is represented in pictures to be riding.

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[*] *Plin. Hist. Nat.*, lib. ix. cap. 32. *Donovan's British Shells*, vol. iii., pl. 84. *Dictionnaire de Trevoux*, Art. ESCARGOT. *Le Clerc's Hist. Mod. de Russie. Statistique de France. Say's Am. Conchology, Helix. Introd.* The information respecting the Romans, is chiefly from Varro, *De Re Rusticâ*, a copy of which the writer has not been able to meet with, and has therefore drawn his information from extracts. Those who have it in their power to consult the original, will, he believes, find more extended information on the subject.

XXVII. CAMEOS or *Camaieux*, are in the present day frequently made from shells. The word properly applies to the onyx stone, whether cut or not, and which is formed of layers of different colours, so that when cut the ground appears of one hue, and the figure of another. The derivation of the name is *Camehuia*, an oriental word, signifying *another stone*, or *one stone placed on another*. The shells employed are from the Mediterranean, but we have not been able to ascertain the species—the genus we understand to be *Venus*. The outer coat is white, the interior layers dark red, and being very hard, admit of a fine polish. They are cut with the lapidary's mill. The substitution of shells for stones, appears to be a very modern invention. False cameos are made of pieces of glass of different colours luted together, and afterwards either cut or cast, according to the figure. It is these which are now so common and sold at so low a price [†].

XXVIII. SHELLS have long been used by the ladies in making fancy work; sixty or seventy years since, this was particularly the fashion in Europe, and large *grottos*, on which extravagant sums had been expended were not uncommon, besides a multiplicity of fancy work in shells of all sorts. Mr. Hughes, in his *History of Barbadoes* has two folio pages, vindicating the ladies against the imputation of extravagance and waste of time in their passion for this shell work, but his argument goes rather to prove that this pursuit is *more* improving than many others which the fair sex of his time followed, than that it is altogether such as ought to engross their minds to the extent it did. Though this taste is disappearing, shells are still in this country made into fancy baskets, vases, ornaments for head-dresses, &c., the manufacture of which is chiefly carried on as a real art, and for profit, and as such, is of course as valuable, as far as it goes, as any other branch of ornamental industry. Articles thus made are admitted for competition at the fairs of the American Institute in New York [‡]. Though all species are occasionally used, the principal seem to be the rice shell, (*Voluta oryza*,) the rose shell, (*Cypræa sulcata? immature*,) the green shell, (*Nerita viridis*,) some species of Tellina, &c. &c. from the West Indies. At Taranto, shell work is a regular business, but the articles are chiefly pictures, resembling mosaic work, picture frames, &c. The shells are stuck one by one, according to their shades, upon pasteboard, on which lines have previously been drawn. The articles are very expensive, and being of course of little use, they are purchased rather as curiosities than otherwise. There are also some manufactures of a like nature in France[*].

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[*] *Dillwyn's Des. Cat.* *Marsden's History of Sumatra.*

[†] *Chalmers' Commercial Dictionary.* *Dictionnaire de Trevoux*, Art. ONYX.

[‡] At the October Fair, 1836, a diploma was granted by this Society "for a beautiful shell miniature church."—Journal of *the Am. Institute.*

XXIX. Some of the Indian tribes west of the Rocky Mountains make use of various coloured shells, ground to an oval, or nearly round shape, as a circulating medium. The same use is made by the Indians of the eastern coast of wampum, or strings of beads cut from the *Venus mercenaria*, (Linn.) and other shells, as well as for a register of events, or history of their nation. The Indians likewise use the wampum as instruments of treaty, and as *speech belts*, or letters to convene a meeting of the sachems, when such is required for consultation[†].

The New Zealanders use shells and beads of mother-of-pearl as necklaces, bracelets, and amulets, and also stud their baskets and aprons with the same[‡]. Being beautiful, and easily obtained, we find shells used by most savage nations as ornaments, and frequently as instruments and utensils for cutting with, drinking from, &c.

XXX. The Brahmins of Hindoostan make their astronomical observations by means of shells arranged before them on the ground, and the Egyptians and even the ancient Greeks are said to have used shells in counting and calculations[§].

XXXI. At Mobile, shells are used in mending the roads, for which purpose they are said to answer well.

XXXII. By some of the aborigines of the coast of South America, a large bivalve, full of grain, was buried with the body, to feed it during its travels to the next world.

XXXIII. The stony operculum of some species of East Indian *Turbo*, are used as "*eye stones*," to remove dust, &c. from the eye.

XXXIV. Bivalves were used by the Greeks and Romans in the ostracism, the name of the person to be banished being written on the shell. Whether the Romans ever made use of the shells for this purpose has been doubted; though at first they perhaps might, and afterwards only the earthenware tiles, to which the Greek name *οστρακον* was transferred.

[*From* SILLIMAN'S JOURNAL.]

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[*] *Hon. Keppel Craven's Tour through the Southern Provinces of Naples. Hughes' History of Barbadoes, &c.*

[†] *Hunter's Manners and Customs of several Indian Tribes. Marshall's Life of Washington.*

[‡] *Cook's Voyages*, where plates of these articles are given.

[§] *Playfair on the Astronomy of the Brahmins, in Transactions of Royal Society of Edinburgh*, vol. ii. *Herodotus*, lib. ii. cap. 36.

ON GEOGRAPHICAL AND GEOLOGICAL MAPS.

THE majority of readers only apply the term *geography* to one division of that extensive branch of knowledge, if that can be called a division which is neither very precise in its limits, nor in the subjects it comprehends; such as it is, it ought to be called *political geography*, since it consists principally of an enumeration of the cities, towns, &c., which are found within certain imaginary boundaries of portions of the earth's surface, arbitrarily established by political conventions; and of the relative positions of these countries, towns, &c. *Physical* geography, or the science properly so named, on the contrary, treats of the present constitution of the earth's surface, and of the effects which its inequality in level, and its irregular division into land and water, have upon climate, and consequently on its organic productions and their distribution.

Many of the subjects with which geography is conversant, in any acceptation of the word, admit of being presented to the mind by means of *maps*. Maps are a kind of *pictures* of portions of the earth's surface, conventional characters being used to express those features which cannot be properly delineated; as long as the map is intended for the purposes of political geography only, a representation of the outline of the land, waters, and the courses of the rivers, is sufficient, and may be obtained with mathematical precision by means of geometrical projection or perspective.

Accustomed as all are, from their earliest infancy, to consult maps, it is only by an effort of judgment that we can divest ourselves of the effects of association, and free the information which maps are intended to impart, from the erroneous impressions attendant on this mode of conveying it. Not two in a thousand who look at a map, are really aware of what they are looking at; they know that the object of a map is primarily to show the relative distances of certain points on the surface of the earth, and the *form* of the land and waters composing it, but they are seldom aware that no map ever does, or can, accomplish this; that no distance, or form, on a *spherical* surface, *can* be represented of its true proportions on a plane one, and that it is only by taking a very small portion of the spherical surface at a time, that any tolerable approximation to accuracy in this respect can be obtained. Hence, no general map of the world, or even of only one continent, fulfils its primary object; and without being aware of the kind of *projection* employed, and of its effects in distorting the forms of portions of the spherical surface represented, it is impossible to rectify in the mind the false impression received by the eye.

On the projection called *stereographic*, which is that most commonly used for maps of the world, the forms on the concave hemisphere are projected on a plane passing through the centre of the sphere, by right lines drawn to a point in the opposite spherical surface immediately perpendicular to the centre of the plane and sphere. In this projection the equal distances from meridian to meridian, on any parallel of latitude, are represented on the plane by distances *increasing* as they approach the circle formed by the intersection of the solid with the plane of projection. All the parts of a map constructed on this projection are represented too large in proportion to those at the centre, and the more so as they recede from it. There is a distance of the point of projection from the spherical surface which will cause equal distances on the concave hemisphere to be projected into *nearly* equal distances on the plane, before mentioned as passing through the centre of the sphere; and it is by this, called the *globular* projection, and by this only, that tolerable accuracy in this respect can be obtained. Unfortunately, the practical difficulty of drawing the ellipses, which in this case represent the circular meridians and parallels of latitude, prevents this projection from being employed[*].

The third method of constructing maps of the world is by what is called *Mercator's* projection, which, with respect to the representation of proportional form and distances of the spherical surface, is the worst of all; great as are the advantages it otherwise possesses. A series of equidistant, *parallel*, straight lines, being taken to represent equidistant meridians, which *intersect* at the poles on the sphere, the really decreasing degrees of *longitude*, which diminish as they recede from the equator towards the poles, are represented everywhere on the *map* by *equal* degrees; while the really equal degrees of *latitude* on the *sphere* are represented by distances increasing from the equator in a geometrical ratio, in order to make them, at every parallel, bear the true ratio to the erroneous degrees of longitude[†].

There is another projection occasionally used for general maps, which supposes the eye, or point of projection, to be in the centre of the sphere, and the plane of projection to touch the spherical surface at some point of the equator. On this *gnomonic* projection, as it is termed, from its application to dialling, equidistant meridians are correctly represented by equidistant parallel straight lines, as in Mercator's, but in the gnomonic, the parallels of latitude are projected into hyperbolas. On this projection it is impossible to represent half the sphere on one map, and for more than a sixth of the circumference in any direction, the distortion becomes excessive.

If the plane of projection be assumed touching the pole, or as being perpendicular to the axis of the globe, then the meridians will be projected into straight lines radiating from the projected pole, and all parallels of latitude will be projected into *circles*, whatever may be the kind of projection. The facility of construction in this case would render this the best of all; but unfortunately it is not maps of circumpolar districts that are often wanted, and the parts in this, as in all other cases, are of course equally distorted in proportion as they recede from the centre of the map.

When a proportionably small portion of the spherical surface only is projected on a plane, these causes of distortion of form and distance are materially diminished, and for maps of countries not exceeding Britain or France, they may be disregarded; while they become practically annulled for local maps of counties, &c., because, in the latter case these small portions of such a spherical surface as that of the earth, may, be considered as absolutely plane, and the map becomes a faithful geometrical reduction of them.

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[*] There is a beautiful map of the world *constructed on this* projection, in the *Encyclopædia Metropolitana*, and it is the *only one we know of.*

[†] The advantages of this apparently inconsistent proceeding could not be understood by a reader not conversant with mathematical science, and we refrain from dwelling on the subject, as being foreign to the immediate object of this paper.

Having thus pointed out the sources of erroneous impressions which are inevitable from the fundamental principles on which maps *can* alone be constructed, we will now only briefly allude to those which attend the mode in which they are constructed, on an indefinitely minute scale compared to the magnitudes they are intended to represent. These secondary sources principally arise from the necessary use of conventional symbols, in conjunction with proportional delineation of real form.

Even on a tolerably large scale, the width of roads, and rivers, and the magnitude of towns, as indicated by marks, are considerably too great; and the evil is virtually increased by the name being added. If we examine a map of our own island, what an incorrect idea we should receive, if we trusted only to our senses, of the proportion of space taken up by towns, roads, and rivers; and it must be remembered that these impressions are received in early life before the judgment, confirmed by other pursuits, can be exerted in rectifying them.

Since it appears that the essential principle of a map is that of being a kind of *picture*, it would obviously be desirable to extend this principle, and to render the map a representation, in some degree, of the surface within the contour of the land the proportional forms of which it was originally intended to show; so that the map might convey an idea of the relative inequality of level, of the characteristic differences of soil, as well as of the courses of the rivers, and the direction of the mountain-chains. Of such maps as those to which we now allude we possess none in this country, and difficult as it would confessedly be to realize such a scheme, we think the attempt has not been so fairly made as the importance of the subject demands.

That the proper and more immediate object of geometrical drawing —the representation of outline in its true proportions—is not incompatible with a considerable quantity of pictorial effect, any one will be convinced by looking at an architectural elevation, in which the accurate proportions of the building are uninjured by the addition of light and shade; such a drawing holds a valuable intermediate place between the picture of the artist and the mere diagram of the mathematician; and incalculable would be the service rendered to physical geography, if maps could be constructed on an analogous principle.

Geographical atlases, as they are at present published, consist of outlines of the land and waters literally tinted over with the names of cities, towns, villages, ports, harbours, capes and islands*; such maps are obviously incapable of affording any information as to the physical characters of the earth, or indeed any useful knowledge concerning the towns, &c., except that of their relative situations; and, for the reasons before given, even these situations are so misrepresented as to be nearly useless to any but a geometrician. This multiplicity of words is perfectly incompatible with the delineation of surface we have suggested; fortunately the object for which the names are inserted is, as we have hinted, quite distinct from that we have in view; and it is owing to the disregard of this fact that maps, as they are now compiled, are so much less useful than they might be made. The physico-geographical map ignores the results of congresses and boundary commissions, it has nothing to do with kingdoms or parishes, and since, as will be shown, it requires the utmost skill and taste to express on a map what it ought to represent, we may be well excused from superadding what is foreign to its object.

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* When we take into consideration the small number of places of which the latitude and longitude are determined with anything like precision, and our total ignorance of the relative position, or even the existence, of many, or most, of the subordinate towns over a large part of the inhabited world, the absurdity of crowding a map with names ill-spelt, and often inserted *at random, on the most suspicious authority, must be obvious to* any one who takes the trouble to think upon the matter; formerly—

> Geographers in Afric maps,
> With savage pictures filled their gaps;
> And o'er unhabitable downs
> Placed elephants, for want of towns.

The practice of *modern* geographers is not a whit less ridiculous; they frequently fill their gaps with towns which have no existence except on paper.

We purpose now to give a few hints as to what should be attempted in the construction of a really useful atlas of physical geography, and on the practical mode of accomplishing it. The principal characteristics of the earth's surface, which may and ought to be represented by means of maps, are:

First, the variations in level *, causing mountain chains, hills, valleys, table lands, &c.; the courses of the rivers and streams, and the indentations of the coast, being governed by these inequalities in level, these important features of a country can be most advantageously represented together; unfortunately the comparative altitudes of different spots above the level of the sea, have only been observed for too few places to furnish data for an accurate map; but when we take into consideration the smallness of the scale on which maps are necessarily constructed, it is clear that, except on maps of small districts to a comparatively large scale, it is only the principal mountain chains and lines of hills, the great basins and valleys, and the difference in level of extensive table lands, that can be expressed.

Secondly, the variation in the nature of the surface, depending on the soil or rock constituting it; this leads us to the consideration of what are called *geological* maps, in which the different strata and rocks composing the crust of the globe, are shown as they appear in succession at that surface; in order to indicate the numerous characteristic differences of these strata, &c., as well as to point out their crystalline or mechanical, their igneous or aqueous origin, so much outline and so many shades of colour are required, that it is impossible to express distinctly any variation in level compatibly with this more immediate object.

One great secret, which it appears we have yet to learn in order to make maps useful, is not to attempt too much at a time; we have several geological maps lying before us, and few are free from this defect, in many cases arising, as it appears to us, from a want of perception of the marked difference between political and physical geography: in their anxiety to make their maps comprehensive, the compilers have introduced every thing that a map can contain, and the confusion produced by so doing materially lessens their utility with respect to any one of the purposes for which they were intended. The roads, the canals, and the railways, have no immediate connexion with the geology or physico-geography of a country, because neither one nor the other are *solely* governed by the situation of mountains, valleys, rivers, or marshes, but their directions are greatly influenced by the position of towns, and the divisions of counties, &c., fixed before the canals and railways were contemplated. It is quite sufficient for one map to show with clearness and accuracy the roads, navigable rivers and canals, and the railroads of a country, and their connexion with cities, towns, and markets, indicating the bridges, locks, tunnels, &c.; and the same map may contain the ports, harbours, light-houses, shoals and soundings, and all that refers to *navigation*, without interfering with the representation of the inland means of conveyance. But the examples before us prove that the endeavour to combine these, strictly politico-geographical, features with an elaborate map of scientific geological character, is the sure means of defeating both objects.

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*This word is used in its correct sense of inequality of distance from the earth's centre.

Even when maps of the last named species are strictly confined to their geological purposes, no ordinary trouble is requisite to enable them to express all that comes within their proper scope. Anatomists delineate the successive layers of muscles of the body on separate figures, and do not attempt to show those which lie beneath one layer, by dotted lines or conventional symbols, and it would be as well if geologists followed their example. One map might indicate the surface geology only, the mere vegetable soil being supposed removed; another should be devoted to the carboniferous series, showing the coal-fields; and a third to the primary and transition rocks, which contain metallic veins, or the two last might be united in one; but to attempt to combine all three on the same map must be detrimental to the distinctness with which either of these three features can be expressed.

Having endeavoured to show why these different subjects for maps should be kept distinct, we shall now proceed to explain how the surface-geology may be combined with the indications of the variety in level of that surface, as we think ought to be the case, in order to produce an instructive map of physical geography. Indeed, unless this be done, the map of the surface-geology only is comparatively unintelligible, and consequently uninstructive; the appearance of small patches of crystalline rocks amid extensive mechanical deposits may be explained, if the former are shown as protruding through the latter and lifting up their edges into ridges on the flanks of the igneous ones. On the same principle, anticlinal lines, and their relation to the country on each side of them, may be made more palpable; and great basins, such as the Wealden, Isle of Wight, London, and Paris, &c., should be made to appear as surrounded by ranges of hills. Although these suggestions can only be adopted on partial maps to a large scale, and even then require considerable exaggeration; yet the principle should be borne in mind in constructing all geological maps. Admitting fully the necessity and desirableness of employing colours to distinguish the various *formations*, strata, &c., as they appear at the surface, we must remind the reader that light and shade, by which undulation or change in direction of surface *can alone* be made sensible to the eye in a drawing, may be *expressed in any colour*; but if we appropriate this difference in intensity of the colours for the purposes of light and shade, we deprive ourselves of that resource for additional means of distinguishing variation in the mineralogical or mechanical characters of the strata, or in their relative order of deposition [*], and this constitutes an obstacle to the execution of our plan that can only be surmounted by a compromise. In the first place, it may be remarked that the endeavour to make every thing in a map equally distinct, defeats its own object; when every minutia is intended equally to " to catch the eye," nothing is seen, and the map loses its essential characteristic of being a *representation* of form and surface, and becomes only a *table* of reference; all the *outline* of the most elaborate and complicated map may be retained, and yet the equally important effect of varying surface portrayed, by not destroying that breadth of light and shade essential to the end in view [†]. Secondly, differences in the strata may be indicated, consistently with the general tinting, by variations in the kind of line, or *hatching*, by which the engraver expresses surface; this will make these differences distinct to those who look closely, without detriment to the general effect of light and shade, and nothing beyond this ought to be expected.

Direction of the engraved line must be governed by that of the surface to be expressed [‡], but the *style* of the line, and its combinations with dots and cross hatchings at various angles, will furnish a sufficient variety to characterise all the geological peculiarities that require to be palpably indicated.

To remove all obstacles to the fulfilment of our plan, we would banish writing and names altogether from the surface that is occupied by the land, and make the references in the margin by means of small and unobtrusive letters; the situation of principal towns, or other remarkable localities, may be inicdated by dots, to be referred to in the same way, or else by means of an index map.

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[*] For instance, the inferior oolite is distinguished in geological maps from the upper by a darker or lighter tint, without regard to level.

[†] A recent improvement in mechanical engraving might be advantageously adopted towards accomplishing the purpose we are suggesting. If a model of the surface of a country were accurately made to scale, and employed in that process which, whoever may have been its inventor, is known by the name of the "*Procédé de Colas*," from that of the artist who has most successfully applied it, we should obtain a map of the country, accurate in outline, and indicating its characteristics of surface by light and shade; on this, as a basis, any additional geological information may be added by means of colours. Those who have seen the exquisite effects of delicate relief produced by this process, may easily imagine how admirably the surface of a district might be represented, from a model of it made with tolerable attention to accuracy; but for the purpose to which we would apply it, a far lighter general tint, which is produced by making the lines wider apart on the engraving, would be desirable; *and if necessary*, additional shade might be subsequently given where required; the same objections against the application of another line on that produced by the machine not existing in the case of a map as in the case of a work of art.

[‡] Some years ago a German officer, of the name of Siborn, published a work on map drawing and engraving, containing some most valuable observations on the subject, one of which we will here allude to because it illustrates the text. Suppose the waters of a lake, in a mountainous basin, to stand at various altitudes, the *shore* line, at each height, would obviously be one of equal *level*, and these lines of equal level being marked on a map of the mountainous basin, then Siborn proposed that the lines of shading should always be at right angles to them, and the hatching should accurately terminate at them. By then governing the strength of the hatched lines according to a given law, not only would the engraved map express the light and shade produced by the relief of the mountains, but these lines of equal level would be marked out and furnish important topographical information. Of course, in the absence of a lake to give them, their position must be obtained by barometrical observations.

It will be readily conceived, that the foregoing observations must be considerably modified according to the extent of surface to be represented in one map; in a map of Europe, for example, though constructed to the largest practicable scale compatible with publication, the inequalities in surface-level between the great mountain chains, would be too inappreciable to be indicated with fidelity, by light and shade. On such a general map, therefore, only the great basins, as drained by the principal rivers, should be shown, by making the mountain chains and their ramifications distinct, and by taking great care that the courses of the rivers are never at variance with them, as is frequently the case, in maps of considerable pretensions*. On such a general map, only the leading geological features can be portrayed, and to admit of even this being effectually done, the same exclusion of all *writing* must be rigidly adhered to; if this precaution be attended to, the additional features of the isothermal lines, and lines of magnetic variation, may be introduced without causing confusion; but at any event, volcanic districts, and recent volcanoes, may be clearly expressed.

The same general outline of a continent may be employed on another sheet, to serve as the basis of maps of that quarter of the globe at former geological epochs, when we possess any tolerable information on that point†.

But it is principally in constructing maps of small portions of territory, to a large scale, that we would apply the principles we have been advocating; in this way a map of England, which would not be too large for a good-sized folio atlas, might be constructed, to show distinctly the ranges of hills and valleys, their mutual connexion, and their drainage, with the surface-geology, without the necessity for any exaggeration in shading; this exaggeration in existing maps being necessary to overpower the black writing with which they are uselessly loaded. And to maps of still smaller areas, we feel convinced that a degree of vividness with respect to the physical geography of the district, might be conveyed, of which we can form no idea from even the best that are now extant.

In maps hitherto published, no attempt has been made towards accomplishing for the bed of the ocean, that which has been done for the dry land; and yet, though the former must ever be to us a *terra incognita*, we possess more information about the parts adjacent to the existing continents and islands than might at first be supposed; first, in the numerous soundings, and charts of rocks and shoals, obtained for the purposes of navigation; secondly, in the direction of currents and tides, both of which must be influenced, near land, by the form of the bottom. On physico-geographical maps, the information conveyed respecting the land should be extended to the adjacent seas as far as the data admit of its being done; the charts of the coast would furnish us with lines of *equal soundings*, or *submarine levels*, which, in conjunction with the formation of the coast, and the direction and dip of the strata forming it, would carry on the map in imagination, as far as "plummet ever yet has sounded;" and the boundary between the fathomable and unfathomable, which may be also deduced in many cases from the same sources, would furnish valuable information of a negative character. In conjunction with this outline of submarine surface, the direction of currents, the lines of spring and neap tides, the position of sand-banks, rocks, &c., and soundings, are equally valuable to the physico-geographer as to the seaman, in defect of more accurate information of submarine geology. All this information regarding the adjacent coast, can be introduced into the map of the land, without confusion, but the atlas we are describing, would not be complete without general maps, to a moderate scale, of the *ocean only;* in which the inhabited land and larger islands should be left perfectly blank; the tint of the water may express much with regard to the great oceanic currents, such as the gulf-stream, the situation of the principal banks, whether always submerged or not, the boundaries of the ice in northern and southern oceans, and the courses of the icebergs, &c.; the direction of the aërial currents may be marked by arrows; the localities of certain phenomena connected with the organic world may be introduced in this case, without fear of confusion; for example, the limits to which the whales descend towards lower latitudes, the directions and places of appearance of the shoals of migratory fish, as the herring, mackerel, &c.; the distances from land where certain birds are first met with, and the course of flocks of those that annually migrate, as they have been observed at sea; the position and extent in the Atlantic of the great bank of fucus called Sargasso, or gulf-weed, and other valuable analogous facts; and in maps of this kind, of the Pacific and Indian oceans, indications of the progress and existence of coral banks and islands, would be a fertile source of interest.

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* We would cite, as an admirable specimen of a good physico-geographical map of this general description, the *Cartes muettes*, or *Skizzen-karten*, published at Munich, by M. Desjardins; on these beautiful maps the mountains are admirably expressed; the cities and capitals only marked by dots, and the effect uninjured by words of any kind.

† With regard to Europe, Mr. Lyell, in the second volume of his *Principles of Geology*, has given an interesting map, showing the extent of surface covered by water, since the commencement of the deposition of the tertiary series; and M. Boué has published another, of central Europe, when it consisted of separate chains of islands, separated by lagoons and lakes, partaking of fresh-water character. This map, on a larger scale, is to be found in the second series of the *Transactions of the Linnæan Society of Normandy*. We believe that ample data for an analogous map of the British isles, in greater detail, exist, if they have not yet been made use of.

Numerous *sections* of the crust of the earth, ought to accompany and illustrate the *plans* or maps of its surface, and are indispensable for geological purposes; it is impossible to draw these sections to the same scale, as regards the horizontal and vertical distances, for the latter could not be distinguishable if made to the same scale as the former. To counteract the erroneous impression the mind receives from this cause, especially with regard to the thickness and angle of inclination of the various strata, each such factitious section should be accompanied by one, in the simplest outline, drawn correctly to scale in every respect, and having the great geological formations, or series of beds, marked on it at their proper inclination.

Another important branch of physical geography which admits of being illustrated by the aid of maps, or of something partaking of their character, is the distribution of organic creation. Schouw, a Danish professor, published a series of twelve plain outline maps of the world, showing, by means of colours, the extent to which as many principal natural orders of plants were distributed. Thus, for example, the fact of the existence of the order Compositæ in every known part of the globe, is clearly presented to the mind by the *whole* of the map being tinted yellow: the colour green extending over a great part of the northern hemisphere only, indicated the presence of Graminæ, and their comparative absence from the southern. The habitat of Ericæ and Epacridæ, confined to the Capè of Good Hope and Australasia, is made equally apparent, and so on. This series of maps, corrected and extended according to the present state of our knowledge of botanical geography, ought to form a part of our proposed atlas; but the method adopted by Humboldt, in his *Tableau des Regions équinoxiales*, admits of extension, and affords an opportunity of combining several geographical particulars, and of presenting them at one view. This plan consists in giving the profiles of the principal mountains, not only showing their relative altitudes, and the lines of perpetual snow, but the species of plants that clothe, and of animals that inhabit, their flanks.

Of the multitude of charts of "heights of mountains" that have been hitherto published, not one is free from the fault we have pointed out,—that of crowding too much in one sheet of paper,—and most are deficient either in accuracy, or taste, or both. The scheme we would suggest consists of giving on one line as a base, taken to represent any parallel of latitude, a series of the profiles of all the mountains found on that parallel, or at a certain distance on one side of it; these latter may be grouped behind those which are immediately on the line in a way to convey the idea of their relative distances from those immediately on the parallel. It need hardly be observed that this sectional line cannot, any more than the simple geological sections, be drawn to the same scale as regards their altitudes and the distances in longitude that the mountains are situated one from another; but these latter distances should, nevertheless, be kept in their proper proportions: this, perhaps, would preclude the possibility of bringing one whole parallel within one, or even three maps, but the full spaces of intervening seas being reduced, will greatly abridge the length to which this conformity to relative distance would otherwise extend the line. The advantage attending the preservation of these proportional distances is, that the connexion may be shown between the undulation in altitude of the line of perpetual snow on one parallel, and the isothermal lines on the map.

Though it would be impossible to make the mountains anything like faithful portraits, yet attention may be paid to their characterstic forms and outlines, depending on their geological structure; and all meteorological facts connected with them, that can be expressed pictorially, may be indicated, such as their being usually cloudcapped or the reverse, and if they are volcanic, the height to which the vapours usually ascend, and the direction they subsequently take. But though a considerable degree of taste and pictorial effect may be shown, yet of course, in this case, we cannot dispense with writing. The vegetation of the mountains might in some degree be characterised, but utility being the primary object, the names of the species and genera must be written, and the habitat of animals can only be thus indicated. All *above* the horizontal base-line must be strictly drawn as a geometrical profile; *beneath*, however, we would suggest a kind of bird's-eye view, or map, of the adjacent plains, by which means a great mass of curious information may be added, and the geology, zoology, and botany of the parallel at the general surface presented in connexion with that of the mountain chains. If a lake lie within the prescribed limits, its characteristic features may be given, or, what would be still better, where data for it exist, a section on the line of the parallel, on which section the probable formations and deposits should be indicated, and the various species of vertebrated and molluscous animals resorting to, and frequenting its waters, recorded. In the same manner the portions of the profile left to indicate the places where the parallel crosses the ocean, may be made available to record the marine natural history of the latitude.

In concluding these hints for an atlas of physical geography, we would urge one point, without attention to which, no taste in execution, no expense in publication, would be of any value: we mean scrupulous veracity and accuracy; we should prefer seeing half a map left blank, to seeing it filled up by guess or by *cookery*. If this conscientious proceeding be productive of mortification,—by showing, from such numerous hiatuses as would in that case appear, how little progress we have made towards a knowledge of the world we inhabit,—yet it might, on the other hand, be of greater service, by showing at a glance to what quarter observation should be directed, in order to fill up a deficient portion of outline on any one subject. We would not, for the sake of a niggardly economy, render the set of maps incomplete by omitting those which, when weighed in the judicial balance, and purified from that which was found wanting in authenticity, presented but a meagre body of matter, nor by crowding into one map what would make but a sorry figure when distributed, as it ought to be, on two or more. Indeed, it will be immediately seen that, in sketching out our plan, we have totally disregarded those petty commercial considerations which booksellers would urge against it, representing the saving of expense that would accrue in printing and engraving, by combining as much as possible on one map. We have been indulging in the day-dream of a national work, which will never be realized in this country, till our government begins to aid and encourage science, instead of repressing it by vexatious exactions or by cold neglect, or till some company of individuals rise up who will prefer the promotion of knowledge to their own profits*. That both of these are *possible* events in any nation, the work on Egypt of Denon, Humboldt's *Tableau des Regions équinoxiales*, the *Florentine Gallery*, and a multitude of other works published in France, Italy, and Germany, without regard to expense, and distinguished for accuracy and taste, sufficiently prove, but it will be long before any English work of equal merit swells the list.

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* One such disinterested society does exist, instituted on this honourable principle, and the national benefits it has conferred are not acknowledged as they deserve to be. We regret that the atlas *of the Society* for the Diffusion of Useful *Knowledge is liable* to the same objections that we have urged against these publications in general. It is entirely politico-geographical, and in that respect even possesses no peculiar merits except its moderate price,—a merit, however, of a very high order, which we by no means underrate.

MISCELLANEA.

New Term in Science.

Berzelius has recently promulgated a scientific term to distinguish that force by which a new combination takes place between the elements of a body; the term is *catalysis*, expressing the converse of *analysis*, which implies the resolution of a compound into its separate elements. A *catalytic effect* is that which is produced by the force alluded to, and a substance is termed *catalyzing*, which, without itself undergoing any modification, produces a *catalytic effect*, or a modification in the previous arrangement of the constituent principles of another body.

Thus, for example, sulphuric acid much diluted with water produces, by the aid of heat, the successive transformation of starch (fecula), first into gum and subsequently into sugar, without either adding to or subtracting from any component element of this substance, which only takes more or less water (of *Hydratition ?*) from the liquid.

Diastase is a vegetable principle recently discovered in germinating barley, and in all those plants in the nutrition of which fecula performs an important part; diastase produces still more effectively the transformation of fecula first into a gum, which has been called *Dextrin*, (see Vol. IV., p. 233,) and afterwards into sugar analogous to that obtained from the grape.

Now, in this instance also, the only modification produced is in the arrangement of the component elements of the fecula, while the *catalyzing* body, the diastase, only acts as the determining cause of that modification. It may be said that, in this case, the catalyzing body brings about, at a certain temperature, a modification which, without its action, could only have occurred at a much higher temperature.

As another and more striking example, the transformation of alcohol into ether may be mentioned. These two compounds, as is well known, only differ in the proportion of water which the alcohol parts with in producing the ether. It was at first imagined that, in this transformation, the sulphuric acid acted by taking up the water from the alcohol; but a recent experiment has shown that, if acid mingled with an equal weight of water be employed, and that if the alcohol be added so as to avoid too great an elevation of the temperature of the liquid, precisely as much water and ether would be obtained by distillation as enters into the composition of the alcohol employed. Hence the sulphuric acid only acts by a *catalytic* effect: it determines a different arrangement of the component elements of the alcohol.

Since in the living vegetable, diastase produces the transformation of the fecula into other substances capable of contributing to the nutrition of the plant, it may be presumed that in many other of the phenomena of nutrition and assimilation, a real catalytic effect is produced.

Deleterious Effects of Potato-Brandy.

It appears that when brandy is distilled from potato-pulp, a portion of the principle termed *Solanine*, as residing in the plants of that dangerous family the *Solanaceæ*[*], passes over in the process, rendering the product extremely deleterious; and further, by the preparation which the pulp undergoes to fit it for the still, a certain quantity of hydrocyanic acid is developed, still further enhancing the pernicious effects of this spirit.

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[*] The Henbane (*Hyoscyamus*), Belladonna (*Atropa*), Nightshade (*Solanum*), are genera of the order; the potato is a species of that last named.

Explosion of Steam Boilers.

The question whether any explosive gas is ever formed in a boiler, is as unsettled as ever. M. le Baron Seguier is on the affirmative side, and states that a M. Marqué, of the Fauxbourg St. Antoine, absolutely kindled some gas which issued at the safety-valve of his boiler, having previously perceived an odour which made him believe that hydrogen was escaping from it. M. Seguier does not pretend to account for the hydrogen, being uncertain whether it arose from the decomposition of the water (?) or from that of some extraneous substance introduced into the boiler along with it. However this may be, the baron, in common with most English engineers, acknowledges that the principal, and nearly sole, cause of explosions arises from the sudden generation of a large body of steam, in consequence of the water coming in contact with the over-heated sides of the boiler. Considering the question, therefore, as of no moment in a practical point of view, it is still a proper object of experiment, to ascertain, whether decomposition of the water can ever be effected, or whether a disengagement of explosive gases may arise from that of extraneous matters, liable to be introduced into the boiler with the water.

Novel Mode of destroying Insects.

The vineyards in the Maçonnais have been extensively injured by the ravages of a kind of moth of the genus *Pyrala*, when in the larva state. The lateness of the season at which any steps were taken on the subject, prevented M. Andouin, who had been deputed to inquire into the evil, from putting any effectual stop to it at present, the insects having mostly passed into their perfect and innocuous state; but he adopted the following novel and ingenious mode of destroying the moths, in order to limit the recurrence of their numbers next year.

He placed small lamps in flat saucers on the ground, and covered them over with transparent bells (glasses?) smeared over with oil: the pyralas, attracted by the light in the dark, approach the glass, and, secured by their wings on touching the oil, are immediately killed by it. Two hundred of these lamps were placed in a vineyard, at the close of day, on the 6th of August, over an area of about two and a half or three acres, and at distances of about twenty-five feet. The lamps burnt about two hours, and on the morrow about 30,000 of the moths were found destroyed on the lamps. Of these about one-fifth only were females, filled with eggs, which would soon have been deposited; and reckoning 150 eggs in each, by this proceeding 900,000 of the future larvæ were destroyed.

The process was repeated subsequently with still greater success, but M. Andouin considering that the method was an expensive one, had recourse to that of setting men, women, and children, to gather the nests of the pyrala, and the consequence was, that from twenty to thirty persons, working for twelve days, destroyed eggs to the amount of 40,182,000. M. Andouin considered this as a more effectual and cheaper course than that of gathering the caterpillars after they are hatched.

On the Verdict of Juries.

M. Poisson, in the introduction to his work on the Chances (*Probabilité*) of the Verdicts pronounced in civil and criminal causes, cites the gradual increase in the number of criminals brought before Juries, which has taken place in England from 1805 to 1832. According to authentic documents, it appears that if this interval be divided into four periods of seven years each; the number of accused in England and Wales only, has been on an average nearly 5000 in each year of the first period; 6000 in each year of the second; 9000 in each year of the third; 13,000 in each year of the fourth, and during the year 1832 only, the last of this last period, it amounted to 21,000.

The actual number of condemnations has augmented in the same periods, but in a greater ratio than that of the accused; the mean ratio of the former *to the latter* has been during the four periods a little below $\frac{60}{100}$, a little above

$\frac{63}{100}$, a little less $\frac{68}{100}$, and very nearly $\frac{70}{100}$. "I do not know, while quoting these results, whether the increase in the number of the accused had continued in the years subsequent to 1832, but new official publications show that this number appears to have become nearly stationary. Its magnitude in 1833 is not known to me; in 1834 it was 22,451; in 1835, 20,942; 1836, 20,713. Now the ratio of convictions has also remained sensibly constant for these three years, and for 1832 the number of convicted to that of accused has been to within $\frac{1}{1000}$ as follows:—

0·712 : : : 0·703 : . : 0·711 : . : 0·718;

which do not differ by $\frac{1}{100}$ from the mean 0·711, and thus furnish a fresh example of the law of large numbers in the moral order of things.

"In France also, in the years 1832-33-34, during which the legislation has been unchanged, this ratio has not varied more than $\frac{1}{100}$, but its approximate value has never exceeded 0·59, so that it has been a little more than $\frac{1}{10}$ less than in England. Nevertheless, if we subtract from the total of condemned those whose punishment has been simple imprisonment, that is to say, nearly $\frac{3}{5}$ of the whole number for England, and only $\frac{1}{2}$ for France, the proportion of the number condemned to a higher punishment will differ but little in the two countries, and this latter number is about $\frac{1}{4}$ that of the accused.

"The ratio under discussion has varied in France, as might be expected, with the legislation; previous to 1831 its approximate value amounted to $\frac{61}{100}$, and of the number of accused nearly $\frac{7}{100}$ were condemned by the *minima* majority of seven voices to five. Subtracting this second fraction from the preceding one, we get $\frac{54}{100}$ for the ratio of convicted by the majority of eight voices to four; a result fully confirmed by the experience of 1831, in which year the law required this majority for a conviction, and in which the ratio of convicted to that of accused has been equal to 0·54. In Belgium the *minima* majority is that of seven to five, as it was in France previously to 1831, and the proportion of convicted is also 60 or $\frac{61}{100}$.

"The verdicts on civil cases equally present constant ratios, conformable to the law of great numbers. In the whole of France the number of judgments submitted to the Royal Courts was annually about 8000, and of this number the proportion of judgments which were confirmed has been, to within $\frac{1}{1000}$,

0·688 . . . 0·676 . . . 0·697

for the years 1832, 1833, 1834, these fractions hardly differing $\frac{1}{100}$ from the mean 0·687.

"It is on the number of times that events of any kind occur, provided the series of proofs has been sufficiently extended to render the ratios of these numbers sensibly constant, that the various applications of the calculus of probabilities are founded, and by no means on the physical or moral nature of the events, on which these calculations do not at all depend."—*Comptes Hebdomadaires des Séances de l'Académie*, No. 10, Sept. 1837.

More Shooting Stars.

M. Arago has announced to the *Académie des Sciences*, that the phenomena seen on the 12th and 13th of November, has been witnessed on the 10th and 11th of August this year. From a quarter past eleven till twenty-six minutes past three, 291 "falling stars" were counted, making 73 per hour; which number would have been still greater if an account had been kept when they first attracted attention, for at that time 104 were counted by a son of M. Arago in fifty minutes. It does not appear that all the meteors moved towards one point; nevertheless, the majority took a direction towards Taurus, which was that they would follow conformably to the motion of the earth. M. Arago promises a further communication on the subject when the observations have been calculated.

The *Académie* also received a notice from M. de la Tremblais, from Châteauroux, stating that, on the 9th of August, he observed in one quarter of the sky alone, more than thirty falling stars; from ten till half past ten o'clock, all appeared towards Pegasus, or a little nearer to Cassiopeia, and followed the direction of a line drawn towards Antinous, some being on one, the others on the opposite side of this line, but all moving parallel to it. On the following night he again counted five or six in the space of a quarter of an hour.

Now it appears that M. Walferdin made similar, but more extensive, observations of the same nature at *Bourbon les Bains* last year, on the 8th of August. The sky being perfectly clear, while looking towards the north he saw a great number of "falling stars," and counted one hundred and fifty-eight in two hours; they moved downwards, deviating more or less from a vertical line.

Bridge over the Nile.

"THE gigantic bridge over the Nile, projected a long time since, is at last about to be realized, and it is supposed it will be completed in six years. This remarkable work will be constructed at the point of the Delta, five leagues below Cairo. Since, in Winter and during part of the Spring, the water in the river is at present much too low to be available for the purposes of irrigation, the bridge will be constructed so as to serve for a dam to keep the water up to the requisite height. The cultivator will thus be spared great labour and anxiety, and will only have to divert the water into the several canals of irrigation.

"It has been calculated that at first 24,000 workmen will be required to change the bed of the river, to raise the dikes, and dig the lateral canals; 340 iron-workers and 650 carpenters are to be drafted from the Arsenal at Alexandria. As it will not be easy to find so many workmen in Egypt, four or five regiments will be employed at these works. The stone will be brought on an iron railroad from the Mountains of Mokatam, two leagues from the Nile."—*Echo du Monde Savant*, 12th of August.

If the foregoing statement be authentic, it is a fresh proof of the injudicious attempts now making by its present ruler to outrun the rational advance in improvement of which this fine country is really capable. Under different moral conditions of every kind, he is copying the ambitious project of a Peter the First, without possessing either his judgment or means.—EDITOR.

Meteor at Pernambuco.

ON the 11th of December last, at half past eleven at night, a brilliant meteor of great diameter was seen over the village of Macao, at the entrance of Reo Assu: it pursued a direction from north to south, and had been seen in Ceara more than sixty leagues off. It burst with a loud explosion almost immediately after its appearance at Macao, and projected an immense number of aërolites over a space more than twenty leagues in diameter: these masses broke through the roofs of many dwellings, and killed or wounded many oxen in the fields; numbers of the stones were found embedded in the sandy plains where none such existed before.

New Antiseptic.

DR. HARE of Philadelphia, by distilling spirit of turpentine with two parts of alcohol, and four of sulphuric acid, obtained a liquid, which when saturated with ammonia, and subjected to a second distillation, proved superior to kreosote in its antiseptic properties. Milk mixed with four parts of a solution of this sulphated essence of turpentine, remained sweet and liquid for five days, whilst a portion of the same milk not so treated, turned sour in twenty-four hours. Two drops, even, of the oil, put into a quart of milk, preserved it from coagulation for nine days; and although it curdled after that period, it did not become putrescent for a month. Portions of meat were kept for several months by the same treatment. Many other essential oils, treated in the same manner, furnish analogous products.

Cyanuret of Potassium.

A NEW and singular product has been found by Mr. Clarke, to be formed in abundance, and to exude in the liquid state through the joints of the brickwork, in the iron furnaces on the Clyde, in which hot-air blasts are employed. The principal ingredient is the cyanuret of potassium, constituting 53 per cent of the salt; the other component is carbonate of potassa, with a small proportion of carbonate of soda. The salt, when treated with nitric acid, yields gas copiously, having the odour of hydrocyanic acid. Saturated with hydrochloric acid, and exhibited to a proto-salt of iron, it does not form Prussian blue: if, on the contrary, proto-sulphate of iron is first added to it, and the precipitate produced by hydrochloric acid be redissolved, a formation of Prussian blue is produced, proving the presence of cyanuret of potassium, and not of the ferro-cyanate of potassa.

Artificial Rubies.

M. GAUDIN has succeeded in obtaining crystals of alumina, resembling in form, colour, cleavage, and composition, the natural ruby. He accomplished this by fusing alum (sulphate of alumina and potassa,) by means of an oxy-hydrogen blowpipe, into a globule, within which were rhomboidal and cubic crystals, having the density and colour of the ruby, scratching rock-crystals, spinelle ruby, topaz, &c. By proceeding in the same manner with ammoniacal alum, combined with $\frac{4}{1000}$ of chromate of potassa calcined together, and made into the form of a cup, he obtained in the concave part, when submitted to the blowpipe, globules of a beautiful red, slightly translucent, some of them having the form and cleavage of the ruby. These globules were analyzed by M. Malaguti, and found to consist of alumina 97, oxide of chromium 1, and silex and calcium 2, being the same proportions as these substances are combined in, in the natural gem.

Solar Rays.

IT is now well ascertained that a beam of solar rays consists of rays of five different kinds; three illuminating, red, blue, and yellow, of calorific rays, and certain others, undistinguishable by our senses, but possessing the power of producing chemical action on substances exposed to them; all these kinds of rays vary in refrangibility, the chemical being most, and the calorific least so. It becomes a matter of great interest in a scientific point of view, and of equal practical utility, to know how each of these kinds of rays may be intercepted, and the others allowed to pass; or to know what substances are *diaphanous*, *diathermanous*, and (a term is yet to be propounded) capable of transmitting the chemical rays.

The greater or less degree of transparency of substances, depending on the relative thickness of the plates, on the coloured rays they absorb or transmit, are facts obvious to all. A somewhat similar law holds with regard to the calorific rays, but those substances which are diaphanous are by no means also diathermous. And a remarkable difference exists in the diathermancy of bodies when transmitting solar heat, or that obtained from terrestrial sources.

Glass, for example, allows the passage of solar heat with little or no diminution, while it arrests nearly all the calorific rays emanating from a lamp or a fire; and M. Melloni, to whom the world is indebted for the most accurate and extensive experiments on the subject, has laid it down as a general law, "that the power of transmitting calorific rays is by no means proportioned to the transparency of the media;" in bodies not regularly crystallized, this power appears to have many affinities to refrangibility, while in crystals it appears, that those possessing a high degree of transparency intercept nearly the whole of the calorific rays, and of others the direct reverse holds true.

Rock-salt is the only body as yet discovered, that transmits the calorific rays from every source; and a plate of this substance, one-tenth of an inch thick, instantaneously transmits 92 parts out of 100 of the calorific rays, from a terrestrial source, while an equal plate of sulphate of copper, more diaphanous than the rock-salt, arrests the whole of such rays. A plate of distilled water transmits only $\frac{11}{100}$ rays, while a plate of liquid carburet of sulphur, equally colourless, and of the same thickness, transmits $\frac{63}{100}$.

The proportions between crown-glass and flint-glass of equal thickness, as regards their diathermancy, are $\frac{49}{100}$ and $\frac{67}{100}$. A plate of well-polished and perfectly-transparent alum (sulphate of alumina and potassa) only ·07 of an inch in thickness, transmitted only $\frac{6}{100}$, while a plate of smoky rock-crystal, 3·3 inches thick, so little transparent that large printed letters on white paper could not be distinguished through it, allowed $\frac{13}{100}$ of calorific rays from the same source to pass. As regards bodies nearly perfectly opaque, pyroligneous acid and Peruvian balsam transmit some rays, but generally speaking, those bodies which totally obstruct the passage of light, obstruct that of heat also.

Mrs. Somerville has been recently making experiments on the powers possessed by different bodies, of transmitting the chemical solar rays; the test she employed, was paper washed over with chloride of silver, this solution being extremely sensible to the action of the chemical rays, and changing its colour when exposed to them. The results of this lady's experiments were, that light coloured *green* glass, perfectly transparent, arrested the chemical rays entirely, the chloride of silver remaining white where covered by the glass, though exposed to a hot sun for upwards of half an hour; and as M. Melloni found that this coloured glass arrests the most refrangible of the calorific rays, we are led to conclude that this coloured glass intercepts the most refrangible portion of the spectrum.

Laminæ of *green* mica also arrest the chemical rays in a great measure, while equal or thicker plates of white mica allow of their transmission. And yet it is not the green *colour* that solely occasions the difference, for an emerald of a lightish hue transmitted these rays with readiness.

Rock-salt transmits the chemical as readily as it does the calorific rays, as do also violet coloured and deep blue glass, the chloride of silver becoming quite brown when covered by a piece of the latter from a common deep-blue finger-glass, a quarter of an inch thick.

Glass of a deep red allows the passage of but few of the chemical rays, whilst garnet of an equally deep colour, transmits them readily. Again, white and blue topaz, beryl, cyanite, amethyst, and other crystalline substances, transmit the chemical rays readily, while yellow beryl, and brown and green tourmaline, arrest them nearly entirely.

Novel and Ingenious method of Printing discovered in America.

A BOARD of any hard wood of an even and close grain, such as box, pear, plum, or walnut, but cut the cross-way of the grain, is made truly level and smooth. Characters, letters, or patterns, at pleasure, are stamped about one-fifth of an inch deep, by means of steel punches, and when the page is completed, the surface is planed down again smooth and level, till the letters are just effaced. The wood is then soaked in hot water, which causes the woody fibre to expand again, which had been compressed by the punches. The result is, that the letters rise up in relief, and impressions can be taken from the board as from a stereotype plate. Blocks prepared in this way may be used for stamping paper-hangings, or calico, if the characters should not be sharp enough for printing letters.

Receipt for Soda-bread.

PUT a pound and a half of good wheaten meal into a large bowl; mix with it two tea-spoonsful of finely-powdered salt; then take a large tea-spoonful of super-carbonate of soda, dissolve it in half a tea-cupful of cold water, and add it to the meal: rub up all intimately together, then pour into the bowl as much very sour buttermilk as will make the whole into soft dough, (it should be as soft as can possibly be handled, and the softer the better;) form it into a cake of about one inch in thickness, and put it into a flat Dutch oven, or frying-pan, with some metallic cover over it, such as an oven-lid or griddle; apply a moderate heat underneath for twenty minutes; then lay some clear, live coals, upon the lid, and keep it so for half an hour longer, (the under-heat being allowed to fall off gradually for the last quarter of an hour,) taking off the cover occasionally, to see that it does not burn.—(American) Farmers' Magazine.

Horticultural Novelty.

M. C. de L'Escalopier, a distinguished horticultural amateur, has communicated to the Council of the French Horticultural Society the following curious fact. The gardener of the hot-house at Montmartre found one of the pitchers of the *Nepenthes distillatoria* entrusted to his care, filled about half full of limpid sweetish water. This phenomenon, which is so well known as a property of this plant in its native equinoctial regions, has never been before observed in these northern climes.

Effects of a Dry Atmosphere, Ventilation, &c.

The clerks and others, daily engaged in the *Long Room* at the Custom House, are subject to a kind of epidemic complaint, arising from a determination of blood to the head, producing flushing of the face, giddiness, coldness in the extremities, and a languid pulse, &c. Dr. Ure was requested to examine into the state of that apartment, and to report on the best mode of thoroughly ventilating it: in pursuance of this object, he found three peculiarities in the atmosphere of the place; first, its uniformity of temperature, seldom varying beyond 62°—64° either way; secondly, its extreme dryness, indicated on one occasion by 70° of Daniell's hygrometer; and thirdly, its negative-electrical state. In these three qualities, the air daily breathed by the inmates of this apartment nearly resembles that of a simoom of the Arabian and African deserts.

Dr. Ure, after alluding to the admirable method of ventilation adopted in our large cotton factories, and to the unaccountable ignorance of it shown in the report of the Parliamentary Committee on the subject of ventilation, states that the same quantity of coal employed in a steam-engine to actuate a rotary fan-ventilator, such as are adopted in the factories alluded to, produces a ventilating effect thirty-eight times greater than that obtained by the consumption of the same fuel in ordinary chimney ventilation. Dr. Ure protests against the false economy of the principle of warming apartments by the slow combustion of a large body of coke, by a slow current of air, as being productive of deleterious effects on those frequenting such apartments. To obtain the maximum of heat from a given quantity of fuel, its combustion should be vivid, and the evolved caloric diffused over the largest possible surface of conducting material, as is done in the modes of warming by steam or hot-water pipes *.

Canal-boat Experiments.

M. Hainguerlot, last July, instituted some experiments on the Canal de l'Ourcq, which fully confirmed the result of those made by John Macneill, Esq., on the Paisley and Glasgow Canals. It may now be considered as ascertained,—

1. That the wave formed by the boat pushing the water before it, moves with a velocity dependent on the section of the canal, and this may be determined in each case by observation, though it depends on hydro-dynamical principles not yet well understood.

2. That while this wave moves with a velocity greater than that of the boat, and therefore precedes it, the wave opposes a resistance to the boat's advance, inversely proportioned to the distance between them.

3. That the minimum of tractive power is required to draw the boat when the velocity of this is sufficiently augmented as to cause the boat to mount on the top of the wave, and to move along with it.

The Canal de l'Ourcq is thirty-six feet wide at the water level, and about a yard and a half deep. The boat was made in England; it was of thin sheet-iron, seventy-five feet long, and six wide; two horses were employed to tow it, and the tow-rope, its situation, and the mode of fixing to the horses, were imitated from those adopted by the English engineers, in the celebrated experiment alluded to.

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* We *suppose, therefore,* that Nott's stoves *are* not salubrious, and Arnot's stoves *not healthy. We are* happy to find our old predilections for a cheerful, blazing, coal-*fire, in a well-constructed* grate, sanctioned by such authority.—(Editor.)

The Language of Sense and Science.

"Wherever agriculture advances, wherever the dominion of man extends, that of the natural Flora retires before it. 'I can find nothing in this district,' writes a shrewd botanist, alluding to the Limagne, 'cultivation has made a desert of it.' Tournefort specifies the *Orchis bifolia* as being found in the *Champs Elysées*, a plant delighting in shade and solitude*, and now a few common grasses are all that spring in this place, from a soil daily trod by an innumerable population. But let us not grieve over such destruction—ample compensation, in other ways, has resulted from it; the devastations we ought justly to deplore, are those caused by collectors of herbaria, who scruple not to destroy the finest harmonies of nature, and who deprive true botanists of interesting subjects of observation; they have even gone so far as to obliterate the *Asplenium petrarcha* from the rocks of Vaucluse."—Auguste Saint-Hilaire *on the Flora of the Loire.*

Statistics of Pauper Idiotcy and Lunacy in Britain.

The proportion which the number of pauper lunatics and idiots bears to the population generally, is greater in the agricultural than in the manufacturing and trading districts. Thus it appears, that there is one lunatic or idiot for every 579 persons in Bedfordshire, one for every 629 in Berkshire, one for every 701 in Bucks, one for every 658 in Dorsetshire, one for every 576 in Herefordshire, one for every 497 in Rutlandshire; on the other hand, there is only one for every 1,427 persons in the West-Riding of Yorkshire, one for every 1,573 in Staffordshire, one for every 1,079 in Middlesex, one for every 1,960 in Lancashire, one for every 1,638 in Durham, one for every 1,497 in Cornwall, one for every 1,482 in Derbyshire, one for every 1,291 in Cheshire. Taking the whole population of England, there is one pauper lunatic, or idiot, for every 1,038 persons, and in Wales, one for every 807 persons: and upon the population of England and Wales together, there is one for every 1,017 persons. The greatest number of lunatics and idots, in proportion to the population, is found in Rutland, where there is one for every 497 persons, and the smallest number in Lancashire, where there is only one for every 1,960 persons. The number of criminal lunatics in England, on the 12th of July last, was 178, of whom 138 were confined in asylums, and 40 in gaols.—*Statistical Journal* for October.

Thermo-electric Battery.

To enable our readers to understand the subjoined extract, we must remind them, that when unequal degrees of heat are applied at the alternate *links* of a metallic chain made of two metals having different powers of conducting heat, an electric current is excited.

"I have just had completed a powerful thermo-electric battery, made on the principle of Melloni's pile, but according to a form adopted by an *artiste* of Amsterdam, one of whose batteries was shown me by Mr. F. Watkins, of Charing Cross. My battery consists of fifty-six pairs of *elements*,—bismuth and antimony; each element is a cylinder, five inches long, and 0·3 of an inch in diameter; these 112 cylinders are ranged vertically, parallel to each other, at ·75 inch apart, and are kept in that position by passing through two thin boards, in which holes are cut to receive them; these boards are supported on fillets, fixed inside of a mahogany case, having neither top nor bottom, and lined with zinc. When all the elements were carefully placed alternately, bismuth and antimony, plaster of Paris mixed up with water to the consistence of cream, was poured in till it filled up the space between the deal boards, and on one side of them up to the edge of the case on the other or upper side, to within three and a half inches of its edge, the case being made to admit of this *construction*. When the plaster was set, the alternate pairs of elements were united by a small copper strip soldered to each element, and the intermediate pairs were similarly united at the lower surface of the pile;—the 112 elements thus forming a continuous chain of alternate links of the two metals, the ends of which, by the arrangement, are contiguous, and carry each a cup to hold mercury as usual.

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* *Our Ray* mentions plants as being found at St. George's Fields, Battersea, *Hyde-Park, Pancras*, &c., which the present race of botanists would as soon think of *looking for* there, as they would in Cheapside.

"This case being set to stand in a shallow trough, containing melting ice, or a solution of any frigorific mixture, while boiling water is poured into the cavity at the upper part, a spark is obtained by a Henry's coil of copper ribbon, on breaking contact, equal to any given by our large magneto-electric apparatus.

"In order, however, to obviate the cavils of those who persist in attributing the electric current in this case partly to voltaic action, I have adopted a contrivance for dispensing with any fluid, and excite my battery by an iron plate made to lie in the cavity at top, without, however, touching the elements,—a method I adopted for the same reason when I used the small Melloni pile to show the thermo-electric spark at our Gallery.

"The extreme sensibility of these elements to thermo-excitement is beautifully shown by the new battery. When the water applied to the upper and lower ends of the elements, only differed in temperature 19°, a spark was immediately obtained, and when the battery is dry, and connected with a delicate astatic needle, deflexion of 30° is instantly produced, by simply breathing into the case, or by holding a hand within it, but not touching any of the elements. I hope shortly to be able to institute a series of experiments in this unexplored field of electric science, and especially relating to the existence or not of voltaic action, when fluid is used to produce the different temperatures."—*Letter to the Editor, from the Superintendent of the* GALLERY OF PRACTICAL SCIENCE, Adelaide Street.

Cornwall Polytechnic School.

THIS admirable institution had its fifth annual exhibition on Wednesday, the 11th inst., and on the two following days. The display of mechanical inventions, improvements, &c., was not quite equal to former years, but there did not appear to be any falling off in the interest which the exhibition excited, or in the zeal of its members. The premiums offered last year were awarded, and the following, added to those unclaimed, for future competition.

A premium of ten pounds by W. T. Praed, Esq., for any subject to be decided on by the Committee, "which might be beneficial to the mining interest."

Captain Jenkins, of Ammas, offered two premiums, one of ten pounds for the best essay on the several descriptions of fishing-boats used on the coasts of Cornwall and the Scilly islands, particularly adverting on their manageableness and capacity, to their qualities under oar and sail, and to their adaptation, particularly as regards safety, to their respective fisheries. The second premium of five pounds, for the best model and working plan of a fishing-boat, or for either on an improved construction.

Henry English, Esq. offers a premium of five pounds, for the best paper on a subject intimately connected with mines, the choice being left to the Committee.

John Taylor, Esq., added five pounds to any prize offered by the Society, for the best mechanical object or improvement.

Nascent Organization.

"THE commencement of all organization eludes our senses; that is, it is impossible to know what passes during the first moments of animal or vegetable life; for even if by magic power any one should divine it, proofs would be wanting to support his assertions, and the truth would be ranked as an hypothesis. What we term nascent organization, properly speaking, is only the state in which we observe the young organization, when we perceive it for the first time. *In these fields of* difficult research, merit consists in approaching as *nearly as possible, to that* origin which will for ever remain unknown to us."—*Extract from a Memoir by* M. MIRBEL *on Vegetable* Tissue.

New Method of preserving Bodies for Dissection.

Among the competitors for the premium bequeathed by M. Montyon, to be given to those who should discover a mode of rendering certain arts, or processes, less noxious, M. Gannal delivered in an account of a process for the above purpose, which deserves to be generally known. It consists in injecting a salt of alumina, dissolved in water, by one of the carotid arteries. A few quarts of the solution are sufficient to preserve a body, freely exposed to the air, from putrefaction, for some months, or even to dry it and convert it into a mummy.

The inventor employed acetate of alumina prepared by acetate of lead, and sulphate of alumina and potassa (alum). Five to six quarts of this acetate of alumina preserves a body five or six months. From two pounds three ounces of common alum, 250 grains of acetate of lead, and two quarts of water, a dose is obtained sufficient to preserve a body four months; and two pounds three ounces of alum simply dissolved in four quarts of water, will suffice to preserve a body two months. This process has been amply tested in Paris, and the conclusion arrived at, that the liquid of M. Gannal permits of the dissection of the prepared subjects during Summer, and of detailed demonstrations being made from them, which never had been possible at that season previously. As many as thirty bodies have been displayed at a time on the anatomical table, seventy pupils performing on them all the operations in succession usually gone through in a course of tuition.

A premium of 8000 francs (320*l.*) was awarded to M. Gannal, by the commissioners, MM. Gay Lussac, Dulong, Chevreul, Savart, and Dumas; these savans having convinced themselves of the efficacy and merits of the method.

Attack on Cuvier, promptly repelled, and lamely justified.

M. Geoffroy Saint-Hilaire, in a geological memoir, inserted in the seventh number of the *Comptes rendus Hebdomadaires des Séances de l'Académie* for August last, published the following passage:—

"Cuvier, impressed with a prudent regard for political conventions, and maintaining a wise reserve as to the future prospects of society, perceived that no new revelations sprung from the bosom of the earth should clash and attack with hostile malignity the revered and ancient revelations of our sacred books. Cuvier was always careful to adhere, in his writings, closely to biblical and historical truths; hence it resulted that ecclesiastical affairs, which in France were directed by a prelate whose word resounded afar, and was received with submission, were by *reciprocity* intimately associated with the scientific acquisitions of geology*."

M. F. Cuvier, in the ninth number for August of the same journal, thus comments on this passage, after quoting it:—

"It is impossible that any one who takes the trouble to interpret this language, and to seek out the meaning, but ill concealed, of these words, can fail to perceive, that in the opinion of their writer, my brother disguised the truth in his discourse on the 'Revolutions of the Globe;' and that for some interested motive, he capitulated with his conscience; in a word, that this discourse does not merit the scientific estimation which is accorded to it, because it was written with *reservations*, and under the influence of political conventions (*convenances politiques*).

"As long as the author to whom I am replying, only reflected on the knowledge and talents of my brother; as long as he only strove to depreciate his labours, and to weaken his scientific reputation, I was far from endeavouring to defend a memory I respect, securely relying for that on the verdict of our colleagues. But now that my brother's honour is attacked, and his pretensions to consideration impugned, and the words I have quoted have been made public in our Transactions, I can no longer preserve silence, and I protest against the obvious meaning of this passage.

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* *No English* phraseology can render the last sentence of this cautiously-worded *attack. We therefore* give the original words;—"Les affaire ecclesiastiques—se *trouverent à leur tour,* par *reciprocité*, tenues au plus près des acquisitions du savoir *de la Géologie.*"

"If M. Geoffroy believes that my brother disguised the truth, and that he intentionally introduced errors in the 'Discourse' alluded to, let him prove it; the means are simple. Let him only recast the 'Discourse;' let him review and discuss the traditions of the principal people of the earth,—their cosmogony, their primitive history, their astronomy; the different revolutions of the globe, its mineralogy, its geographical state, at the principal epochs of its formation; and lastly, the numberless fossils, the age and nature of which must be determined. If he then shows to us, that conclusions different to those my brother drew, inevitably result from these different orders of facts, we will concede; but till this is done, and these proofs are furnished, we are justified, on the most liberal view of the question, in treating the passage against which we are protesting, as frivolous, rash, and destitute of foundation."

To the preceding strictures, M. Geoffroy Saint-Hilaire replied as follows:—

"I entirely repel the interpretation of M. F. Cuvier; the words I made use of faithfully express my thoughts. Far from having had the intention which has been imputed to me, I took pleasure in the very essay which has been attacked, in paying new homage '*to the activity and to the immense labours of our great zoologist*,' (Comptes rendus, p. 192.) to the brilliant qualities of G. Cuvier, a great writer, an indefatigable and sagacious observer, a judicious reformer of methods previously in use (ibid). Cuvier living, I brought forward our serious differences in the arcana of science; now, after the painful event of his decease, I ought to continue the free discussion and developement of my ideas."

Another Mode of preserving large Plants or Shrubs, in a living state, during long voyages.

"HAVING prepared an air-tight case, by carefully covering all the joints, &c., with several strips of cloth, thoroughly glued down to the wood, I mixed up a liquid mortar, composed of potters' clay, cow-dung, and water, which I spread over the stems of the specimens, and into which I dipped their roots. I next surrounded them with damp moss, and packed them tightly in the box with straw, to prevent their being shaken about by the motion of the vessel. I then closed the chest, using the same precautions to render the covering air-tight, that I had employed for the other joints of the wood. This case was forwarded to the Mauritius, where on its arrival it was opened, and the shrubs, &c., found in full leaf, and in flower."—*Extract from a Letter of* M. D'EAUBONNE.

Result of using Hot-air Blasts in the Reduction of Iron.

"DURING the first six months of the year 1829, when all the cast-iron in Clyde Iron-works was made by means of the cold blast, a single ton of cast-iron required for fuel to reduce it 8 tons 1¼ cwt. of coal converted into coke. During the first six months of the following year, while the air was heated to near 300° Fahr., one ton of cast-iron required 5 tons 3¼ cwt. of coal, converted into coke. The saving amounts to 2 tons 18 cwt. on the making of one ton of cast-iron; but from that saving comes to be deducted the coals used in heating the air, which were nearly 8 cwt. The net saving thus was 2½ tons of coal on a single ton of cast-iron. But during that year, 1830, the air was heated no higher than 300° Fahr. The great success, however, of those trials, encouraged Mr. Dunlop, and other iron-masters, to try the effect of a still higher temperature. Nor were their expectations disappointed. The saving of coal was greatly increased; insomuch that, about the beginning of 1831, Mr. Dixon, proprietor of Calder Iron-works, felt himself encouraged to attempt the substitution of raw coal for the coke before in use. Proceeding on the ascertained advantages of the hot blast, the attempt was entirely successful; and, since that period, the *use of raw* coal has extended so far as to be adopted in the *majority of the Scotch* iron-works.

"*The temperature* of the air under blast had now been raised so as to melt lead, and sometimes zinc, and therefore was above 600° Fahr., instead of being only 300°, as in the year 1830.

"The furnace had now become so much elevated in temperature, as to require, around the nozzle of the blowpipes, a precaution borrowed from the finery furnaces, wherein cast-iron is converted into malleable, but seldom, or never, employed where cast-iron is made by means of the cold blast. What is called the *Tweer*, is the opening in the furnace to admit the nozzle of the blowpipe. This opening is of a round, funnel-shape, tapering inwards, and used always to have a cast-iron lining, to protect the other building materials, and to afford them support. This cast-iron lining was just a tapering tube nearly of the shape of the blowpipe, but large enough to admit it freely. Now, under the changes I have been describing, the temperature of the furnace became so hot near the nozzles, as to risk the melting of the cast-iron lining, which, being essential to the *tweer*, is itself commonly called by that name. To prevent such an accident, an old invention called the *water-tweer* was made available. The peculiarity of this tweer consists in the cast-iron lining already described being cast hollow instead of solid, so as to contain water within; and water is kept there, continually changing as it heats, by means of one pipe to admit the water cold, and another to let the water escape when heated.

"During the first six months of the year 1833, when all these changes had been fully brought into operation, one ton of cast-iron was made by means of 2 tons 5¼ cwt. of coal, which had not previously to be converted into coke. Adding to this 8 cwt. of coal for heating, we have 2 tons 13¼ cwts. of coal required to make a ton of iron; whereas, in 1829, when the cold blast was in operation, 8 tons 1¼ cwts. of coal had to be used. This being almost exactly three times as much, we have, from the change of the cold blast to the hot, combined with the use of coal instead of coke, *three times as much iron made from any given weight of splint coal.*

"During the three successive periods that have been specified, the same blowing apparatus was in use, and not the least remarkable effect of Mr. Neilson's invention has been the increase in efficacy of a given quantity of air in the production of iron. The furnaces at Clyde Iron-works, which were at first three, have been increased to four, and the blast machinery being still the same, the following were the successive weekly products of iron during the periods already named, and the successive weekly consumption of fuel put into the furnace, apart from what was used in heating the blast:—

Tons Tons Tons
In 1829, from 3 furnaces, 111 Iron from 403 Coke, from 888 Coal.
In 1830, from 3 furnaces, 162 Iron from 376 Coke, from 836 Coal.
In 1833, from 4 furnaces, 245 Iron from 554 Coal.

"Comparing the products of 1829 with the products of 1833, it will be observed that the blast, in consequence of being heated, has produced more than double the quantity of iron. The fuel consumed in these two periods we cannot compare, since in the former coke was burned, and in the latter, coal. But on comparing the consumption of coke in the years 1829 and 1830, we find that although the product of iron in the latter period was increased, yet the consumption of coke was rather diminished. Hence the increased efficacy of the blast appears to be not greater than was to be expected, from the diminished fuel that had become necessary to smelt a given quantity of iron.

"On the whole, then, the application of the hot blast has caused the same fuel to reduce three times as much iron as before, and the same blast twice as much as before.

"The proportion of the flux required to produce a given weight of the ore, has also been diminished. The amount of this diminution, and other particulars, interesting to practical persons, appear in a tabular statement supplied by Mr. Dunlop.

"The blowing-engine has a steam cylinder of forty inches diameter, and a blowing cylinder of eight feet deep and eighty inches diameter, and goes eighteen strokes a minute. The whole power of the engine was exerted in blowing the three furnaces, as well as in blowing the four, and in both cases there were two tweers of three inches diameter to each furnace. The pressure of the blast was 2½ lbs. to the square inch. The fourth furnace was put into operation after the water-tweers were introduced, and the open spaces around the blowpipes were closed up by luting. The engine then went less than eighteen strokes a minute, in consequence of the too great resistance of the materials contained in three furnaces to the blast in its passage upwards.

"*Materials constituting a charge.*

		Cwt.	qrs.	lbs.
1829.	Coke	5	0	0
	Roasted Ironstone	3	1	14
	Limestone	0	3	16
1830.	Coke	5	0	0
	Roasted Ironstone	5	0	0
	Limestone	1	1	16
1833.	Coal	5	0	0
	Roasted Ironstone	5	0	0
	Limestone	1	0	0

Trans. Royal Soc. Edin.

Improved Camera Lucida.

In August last, it appears that M. Kruine presented to the *Académie des Sciences* an improved form of Wollaston's camera lucida, in which, instead of the solid glass prism, used in the original instrument, a small mirror is employed, set at an adjustable angle to a horizontal piece of plain glass. The image of the object is reflected from the inclined mirror down to the plain glass, and from thence again to the artist's eye, he looking through a space left for the purpose, at the line in which the planes of the two glasses would meet if prolonged. The second reflected image is referred to the paper beneath, and the transparency of the plain glass allows of the point of the pencil being distinctly seen, thus enabling the draughtsman to trace the outline of the object. The merit of this construction is, that it requires none of that effort to render both the pencil and image visible, one or the other disappearing unless the eye were held very steadily at the hole applied to the edge of the prism, in the original instrument.

Mr. Parlour constructed a camera lucida on this improved principle, some months back; at least we have seen one deposited by that gentleman in the Gallery of Practical Science, and can bear testimony to its efficacy, for the purpose it is intended for. In Mr. Parlour's instrument, the plain glass is deeply tinged red, thus rendering the reflected image more distinct, by toning down the whiteness of the drawing-paper seen through it.

Remarkable Geological Phenomenon.

The position of coal, properly so called, with relation to the other strata of the globe, has been hitherto found to be so uniformly constant, that no European geologist would scruple to decide on the probability, or even possibility, or not, of finding coal in any other than in certain formations, which, as our readers know, are above the gneiss and mica-schist system, indeed above all the stratified primary rocks, and below that singular characteristic formation, which, from its including rock-salt, has been called *saliferous*. Whenever coal is found above this formation, it bears evident marks of being deposited under different circumstances, and possesses very different qualities, its vegetable origin being more apparent, this, from its comparatively recent deposition, not being so completely cancelled as it is in the genuine coal. Of this secondary coal, there is every possible variety to be found in succession upwards, from the boggy peat, now in process of formation, down through *lignites* of every kind to arthracite.

In France, however, the singular discovery has recently been made, near to the village of St. Martin la Garenne, in the department of the Seine and

Oise, of real, veritable coal, having all the mineral peculiarities of that production, but reposing on the plastic clay of the tertiary formation, and under the lower marine calcareous beds of the Paris basin.

We need hardly observe that, assuming the fact to be so, it in no way invalidates the accuracy of the reasoning on which Dolomieu himself asserted, that it was impossible coal could ever be found in that very spot, when he visited the place, in consequence of beds of lignite being discovered under circumstances which gave rise to the hope of real coal existing beneath. Influenced by this authority, no further search was made at that time; and it is only a few months ago that it was accidentally discovered that coal did exist there, and in considerable quantities. Although the coal thus formed appears to partake of all the *mineral* properties of that of the carboniferous system, yet it is in truth a tertiary deposit of lignite, which from certain unknown peculiarities of situation, time, and subsequent catastrophes, has undergone, in a comparatively brief period, those transformations which have converted the lignites of the carboniferous era into coal.

We doubt not that the importance of the discovery, both in an economic and scientific point of view, will induce numbers to visit the spot; and since it appears there is a gradual transition from a lignite to the coal, a new and striking light will be thrown on the natural history of this singular and invaluable product. One thing we may safely predict concerning it; when the families of the plants which constitute the mass come to be ascertained, they will not be found to consist of gigantic Equisetaceæ, of extinct arboreal ferns, Cycadaceæ, and allied families, which characterise the carboniferous coal; but will be found to be the remains of dicotyledonous plants; with but a small proportion of those other classes, which, on the contrary, form the staple of the vegetation existing during the carboniferous epoch.

Patent-Law Grievance. No. XX.

THE inventors of this country, and the introducers of inventions of other countries into this, were obliged to pay down to the attorney-general and other agents, &c., of the Government, during the ten years ending December, 1834, more than £313,000, and during the past year above £42,000 (being at the rate of £420,000 in ten years.) It is to be observed that these enormous extortions are *exclusive* of the drawings, engrossings, and all the other charges of the patent-solicitor.

The penalties inflicted on the inventive genius of Britain during the *present* year, up to the 25th ult., in the shape of government stamps and fees on patents, amount to more than £32,000!

N.B. This sum has been paid in *ready money* on taking the first steps, and as many of the inventors are poor men, (*Operatives*,) and a great many others of them persons to whom it would be very inconvenient to pay at least £100 down, they have been obliged to go into debt, or mortgage or dispose of their inventions, either wholly or in part, &c.

NEW PATENTS. 1837.

N. B.—The first Date annexed to each Patent, is that on which it was sealed and granted; the second, that on or before which the Specification must be delivered and enrolled.——The abbreviation *For. Comm.*, signifies that the invention &c., is "a communication from a foreigner residing abroad."

September *contd.*

169. Thomas Simmons Mackintosh, Coleman Street, *Lond.*, Engineer; and William Angus Robertson, Islington, *Middx.*, Gent.; for certain improvements in steam-engines. Sept. 28.—March 28.

170. Francis Hoard, Demerara, but now of Liverpool, Esq.; for improvements in making sugar. Sept. 30.—March 30.

171. Jonathan Dickson, Charlotte Street, Blackfriars Road, Engineer; for improvements in steam-engines, and in generating steam. Sept. 30.—March 30.

172. Thomas Clark, Doctor of Medicine, Professor of Chemistry, Aberdeen; for improved apparatus to be used in manufacturing sulphuric acid. Sept. 30.—Mar. 30.

Total, September...12.

October.

173. Joseph Whitworth, Manchester, *Lanc.*, Engineer; for improvements in machinery, tools, or apparatus, for turning, boring, planeing, and cutting metals, and other materials. Oct. 5.—April 5.

174. Ovid Topham, Whitecross Street, *Middx.*, Engineer and Millwright; for improvements in the construction of sluice cocks for water-works, and which improved construction of cocks is also applicable to steam, gas, and other purposes. Oct. 5.—April 5.

175. John Loach, Birmingham, *Warw.*, Brass Founder; for improvements in roller-blind furniture, and in the mode of manufacturing the same; part of which improvements are applicable also to other purposes. Oct. 5.—April 5.

176. John Thomas Betts, Smithfield Bars, *Lond.*, Rectifier; for improvements in the process of preparing spirituous liquors, in the making of brandy. Oct. 5.—April 5. *For. Comm.*

177. Antonin Reux de Rigel, Beaufort Buildings, Strand, *Middx.*, Engineer; for improvements in steam-engines. Oct. 14.—April 14.

178. Thomas Vaux, Woodford, *Essex*, Land Surveyor; for improvements in tilling and fertilizing land. Oct. 14.—Ap. 14.

179. Henry Quentin Tenneson, late of Paris, but now of Leicester Square, *Middx.*, Gent.; for an improved construction of the portable vessels used for containing portable gas, and of the apparatus or machinery used for compressing such gas therein; and of apparatus or mechanism for regulating the issue or supply of gas, either from a portable vessel, or from a fixed pipe communicating with an ordinary gasometer. *For. Comm.* Oct. 19.—Ap. 19.

180. Edouard François Joseph Duclos, late of Sainsan, in Belgium, but now of Church, *Lanc.*, Gent.; for improvements in manufacturing iron. Oct. 20.—Ap. 20.

181. Henry Robinson Palmer, Great George St., Westminster, Civil Engineer; for improvements in giving motion to barges and other vessels on canals. Oct. 20.—April 20.

182. John Frederick Grosjean, Soho Square *Middx.*, Musical Instrument Maker; for certain improvements on harps, which improvements are applicable to other musical stringed instruments. Oct. 20.—April 20.

183. Miles Berry, Chancery Lane, *Middx.*, Civil Engineer and Mechanical Draftsman; for improvements in the preparation of palm oil, whereby it is rendered applicable to the woollen manufactures, lubricating of machinery, and other useful purposes to which it has not hitherto been applied. Oct. 26.—Ap. 26. *For. Comm.*

184. Miles Berry, Chancery Lane, *Middx.*, Civil Engineer and Mechanical Draftsman; for improvements in machinery for heckling or combing, and preparing and roving hemp, flax, tow, and such other vegetable fibrous substances. Oct. 26.—April 26. *For Comm.*

METEOROLOGICAL JOURNAL FOR SEPTEMBER, 1837; KEPT AT BLACKHEATH ROAD.

Day of Month	Barom. 9 A.M.	Ther. attch.	Barom. 3 P.M.	Ther. attch.	Thermometer Min.	Thermometer Max.	Daily Temp.	Solar Var.	Rad.	Clouds. A.M.	Clouds. P.M.	Winds A.M.	Winds P.M.	Direction of Wind A.M.	Direction of Wind P.M.	Lunation.	WEATHER, &c.
Friday, 1	29·404	64°	29·436	65°	44°5	61°0	52°8	16°5	48	9	8	0	1	NW	SW		*Cold*; dense masses of *cumuli* and *nimbi*, with thunder.
Satur. 2	29·490	63	29·562	64	46·9	62·1	55·5	15·2	44	7	6	1	1	NE	N		Ditto. *Cumulus*, *cum.-strati*, with showers.
SUN. 3	29·700	62	29·746	63	48·0	57·6	52·8	9·6	45	8	8	1	2	NW	NW	●	Overcast, with *cumuli*, *strati*, scanty rain, black night.
Mon. 4	29·950	62	29·956	63	50·1	60·2	55·1	10·1	49	8	8	2	1	N	N		Clouds more broken; fine, P.M.; *cum.-strati*; clear at night.
Tues. 5	29·901	62	29·920	63	43·0	62·3	52·7	19·3	42	5	7	2	2	E	E		Mostly cloudy; light shower.
Wed. 6	30·100	61	30·058	63	43·8	63·0	53·4	19.2	41	5	3	1	0	NE	S		Very fine; *stratus* A.M.
Thurs. 7	29·989	62	29·904	64	48·0	66·4	57·2	18·4	44	5	9	2	2	SW	SW	☽	Do; afternoon and evening overcast; *scud* and wind.
Friday, 8	29·958	64	29·979	65	54·5	64·6	59·6	10·1	51	10	3	0	1	Nly.	S		Rainy night; cloudy till noon; P.M. fine.
Satur. 9	29·916	66	29·796	69	54·2	70·8	62·5	16·6	52	10	5	1	3	S	SW		Morning cloudy and gloomy; P.M. wind and rain in squalls.
SUN. 10	29·950	67	29·988	68	53·6	69·6	61·6	16·0	50	2	5	2	2	wbs	WSW		Fair.
Mon. 11	29·858	67	29·759	69	52·0	68·1	60·0	16·1	49	3	5	1·2	3	SSW	SW		Fine, A.M., with wind; rain at night.
Tues. 12	29·801	66	29·680	68	49·8	63·4	56·6	13·6	50	7	5	0	1	sly.	SE		*Stratus*, A.M.; P.M. fair; *cirrus*; cloudy night.
Wed. 13	29·200	67	29·147	68	49·8	64·5	57·2	14·7	47	5	5	2·3	2	SW	SW		Windy, A.M.; aftn. fair; *scud* and *cumuli*, rain.
Thurs. 14	29·398	66	29·510	66	49·9	61·0	55·5	11·1	47	9	5	3	3	wbN	wbN	○	Windy, *cumuli*, *cum.-strati and nimbi*; cloudy night.
Friday, 15	29·654	65	29·796	66	46·0	58·8	52·4	12·8	43	3	2	1	2	NW	W		Very fine; *cumuli*; air dry and sharp.
Satur. 16	30·051	63	30·012	64	45·0	65·6	55·3	20·6	42	10	6	1	2	S	WSW		Overcast, mild; fine evening.
SUN. 17	30·100	65	30·106	67	57·4	70·0	63·7	12·6	54	5	7	3	3	swbw	WSW		Windy, *scud*, cloudy night.
Mon. 18	30·092	67	30·061	68	60·5	70·5	65·5	10·0	58	9	10	3	3	WSW	WSW		Ditto, ditto, cloudy.
Tues. 19	30·203	69	30·151	71	54·8	73·0	63·9	18·2	53	9	7	1	0	S	sbE		Sultry and oppressive; *scud*.
Wed. 20	30·052	69	29·996	71	60·9	67·5	64·2	6·6	58	0	0	2	2	SE	E		Clear, a breeze, fine night.
Thurs. 21	29·984	70	30.002	71	50·6	66·0	58·3	15·4	49	3	0	2	1	E	E	☾	*Stratus*, A.M.; *scud*; afternoon clear.
Friday, 22	30·115	69	30·111	71	49·8	65·3	57·6	15·5	47	4	0	2	2	E	E		*Stratus* and mist till sunrise; dry, clear.
Satur. 23	30·182	68	30·180	68	50·9	59·6	55·3	8·7	48	0	2	2·4	3	ENE	E		Clear, a gale of wind.
SUN. 24	30·270	65	30·296	65	51·0	58·2	54·6	7·2	48	6	7	3	3	ENE	E		Flying clouds, *cumuli*, strong wind.
Mon. 25	30·375	63	30·348	64	40·2	58·5	49·3	18·3	38½	8	4	1	2	EbN	ENE		*Cum.-strati*, into *nimbi*, with showers, fine night.
Tues. 26	30·342	62	30·285	63	44·3	59·6	52·0	15·3	42	3	9	1	0	EbN	Ely		Fine; at 2 P.M. a *nimbus* with shower and *rainbow*.
Wed. 27	30·154	61	30·106	62	38·8	59·8	49·3	21·0	38	8	10	1	1	NE	NE		Cloudy, scanty rain, cheerless.
Thurs. 28	30·118	62	30·092	63	50·0	61·1	55·6	11·1	48	8	7	1	1	NE	NE		Cloudy; fine clear evening.
Friday, 29	30·102	61	30·053	65	36·3	58·5	47·4	22·2	35	0	0	2	1	E	E	●	Night cold and misty; clear.
Satur. 30	30·022	63	30·000	66	42·2	62·2	52·2	20·0	39	0	2	1	2	E	E		Fog at sunrise; clear and serene.
Mean.	29·948	64	29·935	66	48·89	63·63	56·27	14·74									

Bar. Max. 30·375 on the 25th.
Bar. Min. 29·145 ,, 13th.

Ther. Max. 73·0° on the 19th.
Ther. Min. 36·3° ,, 29th.

Lowest point of Rad. 35°, on the 29th.
Rain fallen (by Crossley's self-registering gauge), 1·246 in.

ON THE GEOGRAPHICAL DISTRIBUTION OF THE PLANTS WHICH ARE USED FOR FOOD.

BY M. ALPHONSE DE CANDOLLE.

[From the *Bibliothèque de Génève*, April, 1836.]

INDIGENOUS vegetation is distributed over the surface of the globe, in conformity with laws purely physical and physiological.

If a species exist in such or such a part of the earth in consequence of some primordial distribution, it spreads in that locality with a vigour regulated by its peculiar organization, according as the species is more or less robust, and more or less proliferous; and according to the physical circumstances, favourable or unfavourable, which it on every side encounters. On the first creation of existing species, these causes must have early extended or modified the limits of each; subsequently, when new generations had ceased to produce marked changes in the organization of pre-existing beings, and when physical circumstances, such as the configuration of land, and temperature, had ceased to vary sensibly, the geographical distribution of species must have arrived at a kind of permanent equilibrium. Even at the present epoch, if man do not in any way interfere, it rarely, though it may occasionally, happens, that a species spreads spontaneously, and maintains its existence beyond the geographical limits formerly known to be peculiar to it; and when such a circumstance does occur, the foreign species is almost always destroyed by some subsequent variation in climate, or else its progress is arrested and subjugated by the compact mass of vegetation that previously covered the soil. In this strife between new and older species, the first occupiers and the more numerous troop remain in possession of the territory, as happens in contests of another kind.

Considered in their natural state, those species which we cultivate are governed by the same laws; like all other plants, they have a certain *habitat*, within the limits of which they spread spontaneously,—that is, without the intervention of the human race. That it is occasionally difficult to ascertain this habitat, must be attributed to certain circumstances which complicate the history of the vegetables submitted to our control.

In some cases we have abandoned an original *species*, for certain *varieties* of it more productive or more agreeable, which have been produced in our gardens or fields; thus the peach, according to the researches of Mr. Knight, is an offspring of the almond, resulting from the cultivation of fifteen or eighteen centuries. We cannot wonder, therefore, if the peach of our gardens is not anywhere found wild. It has also, and more frequently happened, that the original natural country of a species has been completely invaded by the same species when cultivated, so that the wild individuals can no longer find a place to vegetate in, except in our fields, or, at least, can no longer be discriminated from those produced by cultivation. Rice, for example, is indigenous in Southern Asia, but it is no longer found decidedly wild in its primitive territory, the station where it would grow spontaneously (low and inundated regions) having been employed for the cultivation of the plant, so that it would be difficult to distinguish the cultivated rice of these districts, or that which proceeds from it, from the plant truly wild.

Independently of the *natural* country of cultivated species—of that country in which they have always existed without the assistance of man—species have also what may be called an *artificial* country, in which they cannot live and reproduce themselves without the cares we bestow on them. And this artificial country may be further distinguished into a *horticultural* and an *agricultural* country, according as plants are cultivated in our gardens or in the fields. Let us now examine how far the principles of botanical geography are modified by their application to these different countries of cultivated plants.

It has been stated that the limits to the habitats of indigenous plants, which may be called their natural limits, vary but little now, because they depend on causes which became fixed many ages since: it is not so with the artificial countries,—their limits may extend themselves nearly indefinitely, being influenced by the increasing wants and industry of man, modified in each locality, and at each epoch, by commercial causes, by laws or regulations, and even by the simple force of custom, or the caprices of fashion.

It is horticulture especially which extends the artificial limits in an indefinite manner, because the minute cares which are bestowed on a garden, or on a hot-bed, are, comparatively speaking, unlimited; if it were as easy to lower the temperature of a frame as it is to raise it, there would be no impediment to cultivating every species which exists on the surface of the earth in every country. This is the cause which prevents our imitating northern climates in southern countries; consequently horticultural limits extend themselves infinitely less in the south than towards the north. In this latter direction human industry is not arrested by any insurmountable physical obstacle.

The agricultural limits are both more restricted and more constant; they cannot extend themselves beyond certain bounds, since agriculture cannot influence the general conditions of temperature, of solar illumination, and the humidity of the district where it is carried on; unquestionably by proper care, and by a judicious choice of varieties, certain influences of climate may be palliated, and thus the limits of cultivation somewhat advanced. In the south of Russia, for example, it has become customary to *lay* down the vine-stocks on the approach of winter, by which plan the cultivation of that plant is extended beyond the bounds which would otherwise be assigned to it in a country where the winter is so rigorous.

But these cares of the agriculturist are themselves limited by the necessity for obtaining a certain produce, proportioned to the expenses of cultivation. Hence it is the net revenue which ultimately determines the agricultural limits of species, at least as regards those which have been cultivated for centuries, and in those countries where agriculture is generally established. Now, the net produce depends, 1st, on the botanical and *physical* causes which are within the province of botanical geography; *and 2ndly*, on commercial, legislative, and social causes, the consideration of which falls within the domain of the moral and political sciences.

We thus have two categories of causes, sufficiently distinct, and too evident to render it necessary to dwell on that distinction; but it is not so clear, and yet not less important, that these two classes of causes act differently on agricultural limits, according to the cultivated species they are considered as operating on. Certain cultivations are very little influenced by political or commercial events; others, again, depend almost entirely on them. The former ought to be especially studied in a course of botanical geography; the latter have little in connexion with it, and ought only to enter into one in some rare instances, which cannot serve to elucidate the great laws of this branch of botany. Let us proceed to examine the different cultures under this point of view.

If we turn our attention to those abundant productions of a low price, and which are largely consumed, such as the principal alimentary substances, or even certain drinks generally used; it is clear that the cost of carriage would so enhance their value, that every country must be desirous of producing them itself: in this case the limits of cultivation are extended as far as physical causes will allow. The same may be said of those fruits and vegetables which cannot be transported far, and yet which every one is desirous of procuring. If, on the contrary, we turn to those products which are high in price, less generally consumed, and, from their smaller bulk, more easily transported, it would be the interest of certain populations, if that interest were well understood, not to endeavour to produce them, but rather to seek to import them from countries favoured with a more genial climate. Thus corn, the potato, fruit-trees, and ordinary vegetables, are cultivated everywhere where they admit of being so, and where cultivation is understood: the mulberry, cotton, indigo, on the contrary, are rarely cultivated, even to the limits which climate would allow them to be*. The vine, the olive, rice, hemp, flax, &c., are in some measure intermediate between these extremes.

It results from this distinction, that civilization, by increasing the intercourse between mankind, and by destroying the various obstacles which separate different communities, acts upon agricultural limits in two completely different modes. By disseminating species and useful varieties, and by perfecting agriculture, it extends certain indispensable cultures the furthest possible, the produce of which can be sold at a low price, or will not bear transport; this is the case with fodder, with those species which constitute the staple nourishment in each country, with timber-trees, fruit-trees, and with vegetables. But at the same time that the cultivation of fodder, grain for bread, wood, fruit, and vegetables extends itself, and becomes general, that of other produce becomes more and more restricted to those countries which produce them most readily, and which can most readily export them. In each locality those cultivations are abandoned, the produce of which is inferior either in price or quality to that which comes from abroad. On the one hand, the potato and maize, new to our continent compared with corn, are spreading themselves gradually, like this precious cereal, to the furthest possible limits, and are becoming general everywhere, as happened centuries ago with other alimentary plants, such as apples and pears. On the other hand, by the converse process, the cultivation of the sugar-cane has been abandoned now for some hundreds of years in Spain, Sicily, the Canary islands, and in the north of Africa; that of the vine[*] has been given up in the north-west of France, and has long since disappeared from England; that of the olive has withdrawn from some localities in the south of France, and of the north of Italy.

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* It is a delusion to imagine that a relative large quantity of corn is ever transported from one *country to* another. All *those who have paid* attention to the *subject know that this* quantity is small *compared to the mass of* grain produced and consumed in each country; it has more influence on the imagination of the buyers and sellers than on the absolute quantity consumed.—See Jacob on the *Corn Trade.*

It is in vain to attempt to attribute these changes in cultivation to modifications in climate, resulting, for example, from the clearing of forests, and from inclosing. If the climate of France has become, as has been alleged, warmer in summer and colder in winter, the olive, which only suffers from the severity of winter, would have really receded towards the south; but the vine, which misses the warmth of summer in the north-west, ought simultaneously to have advanced towards the north,—instead of this, both have retrograded. In the west of France, maize, which, like the vine, requires summer heat, has advanced towards the north since the time of Arthur Young's Travels, instead of receding, as the vine has done for some centuries. The limit of this last-named plant has, it is true, advanced a little to the north since the last few years; but it was only at the epoch when, owing to commercial restrictions, Germany ceased to be supplied with wines from the south, and thus a factitious price was imparted to the wines of the Rhine and of the adjoining countries.

There appears to be no instance known in which an indispensable culture, nearly exempt from the influence of commercial fluctuations, like that of corn, has ever retrograded in Europe. It is not, therefore, the climate which has changed, but only political, commercial, and social circumstances which have simultaneously varied, and sometimes in opposite directions, the agricultural limits of species.

Formerly indifferent vines were cultivated in Normandy, and even in England, because at that time the wines of Bordeaux and Portugal did not find easy access into those countries. At that period a thousand dangers, a thousand restrictions, limited maritime and internal commerce; each population was forced by circumstances to produce for itself all that could be useful or agreeable to it, without having recourse to other countries; and this, it may be said, *en passant*, is the *beau idéal* which the lovers of restrictions and prohibitions keep in view, though they aim at attaining it by other routes, and by other methods. In those days, instead of custom-houses, they had frequent and arbitrary subsidies; instead of discriminating duties, they had seignorial rights and corporation privileges; the want of roads and canals increased the cost of transport. Little by little all these impediments have been removed, except the custom-duties, and the result is, certain modifications of agricultural limits productive of great benefit to the human race.

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[*] "The fact is certain; M. Arago furnished lately a new proof of it in a discussion in the Chamber of Deputies on the clearing of forests (28th February, 1836.) He stated that the cultivators in the neighbourhood of Amiens competed with others for supplying wine for the table of Philip Augustus."—(See *Mag. of Pop. Science*, Vol. III., p. 191.) I note this fact, but I cannot agree with M. Arago in considering it as proving that the summers in the north of France were formerly warmer than they are now.

There exist other striking differences between the agricultural and the natural limits of plants.

Within the boundary of the *natural* country of a species, it becomes more and more rare in proportion as we approach that boundary, because external circumstances become more and more unfavourable to it. It is not thus with cultivated species, within the extent of their *agricultural* country. Often next to a country covered with vineyards, we find a district entirely destitute of the vine, and where, nevertheless, the vine would, in fact, be productive. This arises from the circumstance that near to the limits of any culture, the sale of the produce is certain, because the neighbouring population consume that produce without producing it. Within the limit, it is to the interest of the cultivator to cultivate, as much as possible, a species which yields abundantly; but if we pass the limit of territory which suits that cultivation, we immediately enter one in which it is completely abandoned, not only because it would no longer be profitable, but also because it is easy to obtain a supply from the neighbouring district. Near the limit at which the cultivation ceases, the cultivator's interest would prompt him to aim at quantity, rather than quality, for the sale is certain, and he never could contend, in respect to the higher qualities, with the products of more favoured regions. This reasoning would be so much the more evident, if applied to a produce more exposed by its nature to the influence of commercial and social laws.

It appears, then, that agricultural limits are frequently influenced by other causes than those which alone determine the natural limits of species. Nevertheless, these two species of limits have some mutual relation: physical circumstances ordinarily act upon a cultivated as on an indigenous plant, so that many of the laws of botanical geography apply to both.

A species is first cultivated in the region which it naturally inhabits, and succeeds better there than anywhere else: thus the simple fact, that tea grows spontaneously in the Indian province of Assam, might induce us to augur that its culture would succeed there as well as in China.

It generally happens that cultivation extends the agricultural limits of a species much farther than those which are natural to it. The potato, which is now disseminated everywhere, is naturally confined to a small part of South America. Nevertheless, there almost always exists some relation between the extension of the natural and agricultural countries of plants.

When it becomes desirable to cultivate a species, difficulties are encountered, which are so much the greater as the natural country of the species is limited; this is evident, since that limitation proves that very special physical conditions are requisite for the existence of the species. If these conditions are connected with the temperature of the seasons, with the humidity of the atmosphere,—in short, with those conditions which cannot be artificially produced in the open country, it will *follow that the species* requiring these conditions cannot be cultivated *out of its native* country, and that in this country, even, the *cultivation* is attended with difficulty, as is the case, for example, with our alpine plants. If, on the contrary, the requisite conditions are a light or a manured soil, the protection of the plant during winter, &c., it becomes easy to extend the cultivation, by simply fulfilling these conditions. If we study, ever so cursorily, the natural habitat of the Quinquinas in the cloudy regions of the Andes, that of the greater number of species of the Melastomaceæ, Myrtaceæ, Rubiaceæ, &c., in certain countries which are very hot all the year round, or which are both hot and humid, we can easily conceive why these genera are so difficult of culture, and why botanists allow that species which are the most *endemic* * are the least easily cultivated.

With respect to the choice of country in which a new culture ought to be attempted, it is clear that the geographical distribution of the species must serve as a guide; in this case the connexion between botanical geography and agriculture cannot be mistaken.

Let us now investigate what are the agricultural countries of certain species, and we will select, for examples, those plants which furnish man with his principal aliment, since it is such that are least influenced in their limits by political and commercial causes, and which are better brought within the scope of botanical geography. Of course we must confine ourselves to the species only which constitute the staple of man's food in different countries, for otherwise volumes would not suffice for the subject.

I. Species indigenous to the Old World.

A.—*Cultivated for their Grain or Fruit.*

Graminaceæ (Grasses) (*Cerealia*).

Some plants of the family of Grasses are among the most useful, and those longest cultivated in this country (France); they probably have always had an extensive natural country, since that appears to be a characteristic of the species of this family, when left to themselves. Barley grows spontaneously in Tartary and Sicily †, two countries remote enough apart. Spelt-wheat (*Triticum spelta*) has been found wild in the north of Persia by André Michaux, an accurate naturalist. Various indications, both historical and botanical, lead us to conclude that the districts adjoining Tartary and Persia are the natural countries of wheat, rye, and oats, but they have not hitherto been met with there. Divers authors, Roman and Grecian, believed wheat to be indigenous in Sicily, but this supposition has not been confirmed. Strabo, who is more exact than other ancient writers, says that it grows spontaneously on the banks of the Indus, but this region is so little known that modern botanists cannot form any opinion on the subject. The genus *Triticum* is sufficiently diffused over all Asia to render the assertion far from improbable. It is possible that some day both oats and rye may be found wild in some part of Asia, not yet explored, for botanists are far from being conversant with this vast continent; notwithstanding all their industry, there remain regions of the greatest interest, especially towards the centre and the west, yet to examine.

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* *A species is termed endemic* when it *only grows spontaneously in a* limited *region, compared to other species which* are entitled sporadic.—See De Candolle's Memoir on the Leguminosæ.

† Kunth. Gram.

Until naturalists have explored these regions, it will, perhaps, be best to suspend all conjectures relative to the original habitats of wheat, rye, and oats. All that we can say is, that these plants are not derived from some natural type, as is the case with the peach, the stoneless bread-fruit, and some other cultivated plants; the organization of the flowers and seeds of these cereals, which are perfectly analogous to those of many wild species of Graminaceæ, may be cited in proof of this, as well as the facility with which these plants reproduce themselves, as wild plants do, and lastly, the testimony of the ancient monuments of Egypt and Greece, on which the cereals cultivated at the present day in those countries are seen sculptured If a cultivation of three thousand years' duration has not prevented these plants from being recognised, still more if they have remained identical, it may be affirmed that the anterior cultivation, which at most lasted for an equal period of time, had not been able to disguise the original types of the species. It had not been able so far to destroy the characteristic forms, but that when the wild wheat is put side by side with the cultivated one, they are immediately recognized as belonging to the same species.

If, then, after a century or two of careful and renewed search, wheat, oats, and rye, are not found in a wild state in any region of the earth, we must conclude, either that the primitive country has been submerged by the ocean, which is not very probable, or that this country was the very plains bordering rivers on which wheat, oats, and rye, have been chiefly cultivated from all antiquity. Agriculture must have altered their station, it must have so far invaded it that it would have become impossible to discern, on the same soil, the descendants of the plants which formerly flourished there spontaneously, from the cultivated ones belonging to the same species; just as in the mingled population of an European city, it is not possible to distinguish at a glance the aboriginal population from one of foreign origin, although two such really exist among the inhabitants.

The native countries, then, of many of our Cerealia are unknown, and will probably for ever remain so. Even when it is supposed that that country has been detected, as is the case with barley and spelt-wheat, the fact is not certain; the specimens which appeared wild, as being furthest distant from spots where the plant was cultivated, may, nevertheless, have been the produce of some seeds transported by chance, or of some abandoned cultivation.

Let us now trace the agricultural limits of such Graminaceæ as are cultivated, and let us begin with those which predominate in temperate and northern regions. It is these, according to Grecian mythology, which were consecrated to Ceres, and which, for this reason, merit more particularly to preserve the name of Cereals, a term ordinarily rather vaguely used.

BARLEY.

BARLEY *(Hordeum vulgare)* is the grass cultivated furthest northward *of any; fields of barley* are met with to the extremity of Scotland, in the *Orkneys and Shetland* (61° N.), and even in the Feroe Islands (61° —

62½° N.). It will not succeed in Iceland (63½°–66°), although the industrious inhabitants have made every effort to naturalize some species of cereal[*].

In Western Lapland, the limit is under 70°, near to North Cape. In Russia, the limit is between 67° and 68°, on the borders of the White Sea on the western side, and towards the 66° on the eastern, near to Archangel. In central Siberia, the limit is between 58° and 59° N. lat.

Such is the devious curve which limits the cultivation of barley, and therefore that of the cereals: this line is the limit between agriculture, properly so termed, as being founded on *field* cultivation, and the pastoral or nomadic life of fishers and hunters: it is, then, the boundary between vegeto-animal nourishment, in which vegetables predominate, and such as is almost totally animal. A little further northward, all use of plants ceases, at least as an important object of food, and man feeds on animal matter, as in the Upper Alps, either on such as is the produce of the chase, or of fisheries, according to the locality. I say a little further northward, for even beyond the limit of barley, there lies a narrow and undefined zone, in which certain early sorts of potatoes are cultivated; in which zone snow does not so completely cover the earth, but that some edible lichens, some fruits, some wild barks and roots, may be obtained from it for human nourishment. As the introduction of the potato is recent in these regions compared to that of barley, it is almost everywhere the culture which defines the boundary between agricultural and nomadic life.

Considering the importance of this culture in the North, it is clear that wherever the first stage of civilization has been attained, man will have striven to advance the limits of barley as far as possible towards the Pole. If, then, this cultivation is bounded by a devious curve, as we have stated, it is because circumstances purely physical oppose an insurmountable barrier to its further advance.

The temperature of the different seasons ought to be the principal cause to examine, for a certain degree of heat is evidently the only physical condition in which the hyperborean regions are deficient. Let us follow the curve indicated, and trace what the temperature of the seasons is in the different points of its development.

		MEAN TEMPERATURE, FAHR.		
	LATITUDE.	The Year.	Winter. Dec. Jan. Feb.	Summer. June, July, Aug.
[†] Feroe Isles	61°6′–62°25′	+45°	+39°	+51°
[‡] West Lapland	70°	+33·8	+21·2	+46·2
[§] Russia, at the mouth of the White Sea	66°–68°	+32°	+10·2–8·8	+46·3

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[*] See the Journeys of Olafsen and Povelsen, for an interesting account of the reiterated and fruitless efforts to establish *the culture* of the Cerealia in Iceland.

[†] *Trevelyan. Ed. New Phil. Journ., Jan. 1835.* Four years' observation.

[‡] *From* observations of M. Buch, at North Cape (71° lat.) somewhat modified by comparison with Drontheim, in Norway.

[§] From the temp. of Ulea, as given by M. Wahlenberg, and a multitude of facts lately discussed by MM. Meyer (*Plantæ Labrador*), Schouw, &c. There are no good observations at Archangel.

In the interior of Siberia and America, the limit of possible cultivation, and the temperature of the seasons, are so little known, that it is better not to consider them: the limit of 58°–59° of latitude, given for Siberia, bordering on the Jenissé, might probably be advanced further north, if an industrious population were incited to attempt it. In fact, according to observations, not very satisfactory it must be allowed, made by Gmelin at Kirensk (57½°) near to Lake Baikal, the temperature at that place would be about +4° – 0° in winter, +61° in summer, and consequently about 32° for the year. Now it is evident from the above table, that the mean temperature of the year, and especially that of winter, has little influence on the limit in question. A mean temperature of 46° – 47° in summer, seems on our continent to be the only indispensable condition to the cultivation of barley.

It appears that in the islands of the Atlantic, a mean summer temperature of from 3° – 4° higher is necessary for barley to thrive. Iceland, where this cereal cannot be cultivated, in its southern part, at Reykiawik, possesses a mean temperature, for the year, of 37°; 26½° for winter, and 49° for summer[*]. It should seem that tempestuous rains are the real cause why no cereals can be cultivated in Iceland, as Povelsen and Olafsen have stated, after a detailed examination of the agricultural attempts made in that country.

Thus the limit of barley, in that country where there must exist the strongest motives for cultivating it, varies between 46° – 49° of mean summer temperature. M. Wahlenberg fixed it at 47°, in his Introduction to the *Flora Laponica*. In continental regions, 46½° is sufficient; on islands, the excessive humidity requires to be compensated for by a little more summer heat.

In America, the isotheral line of 46½°, will probably one day be the extreme limit of the Cerealia. At present, agriculture has not penetrated the forests of the north of that continent sufficiently far to allow of the observation being made; but when that time comes, this limit will be of the same importance as in the old world; it traverses northern America tortuously, but for want of observations its course is not well known. On the eastern coast of Labrador it starts nearly from the 56° north latitude, since the temperature of the Moravian establishment at Nain (56¾°) is 24° for the year, 1·3 for winter, and +46° for summer[†]. There is no agriculture in this interesting settlement.

In proportion as we penetrate the interior, the temperature of the seasons becomes more unequal; but Labrador forms an exception, on account of its situation between two seas, which equalises the temperature. At Fort Churchill (59° lat.), on the western coast of Hudson's Bay, the temperature is –19° in winter, +52½° in summer; hence we may presume that the isotheral line in question passes towards the mouth of Hudson's Bay. From that point it must trend a little to the south-west, especially on approaching the Aleutian Isles, for towards the centre of the continent it probably rises towards the north; at least such would be the direction suggested by the analogy of climate which exists between the eastern and western portions of the two great continents of our hemisphere: but the want of thermometric observations, renders all conclusions regarding America vague.

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[*] According to Mackenzie's observations, corrected by M. Meyer (*Plantæ Labrador*, III.), those of Thorslenson, given by M. Schouw (*Europa*, 118), are probably too high, *especially for summer.*

[†] *E. Meyer* (*Plant. Labrad.*, p. 160). These figures are approximative, since the times of observation have rendered necessary the application of the corrections of mean temperature, according to the table of Schouw, founded on the hourly observations of Chiminelli.

The limit of the other cereals will serve to confirm that of barley, for all the annual species of one family, cultivated for the same purpose, have parallel limits.

Barley is cultivated as an alimentary plant as far as the northern limit of rye and oats; southward, it loses its importance, for there it is only employed for the distillation of spirits, or for brewing beer. When we enter the region of vines, these two uses become of still less importance; consequently, in southern countries, barley is very little cultivated.

Between the tropics, this cereal does not enter the plains, since it is less tolerant of heat than any grass that is cultivated; but we shall return to the question of southern limits.

2. Rye.

Rye *(Secale cereale)* is cultivated in Norway as high as the 67° of latitude, and to the 65° – 66° latitude in Sweden. In Russia, its northern limit is not known. It is but little cultivated in Britain, owing to the admirable system of agriculture practised in that country. In fact, it is only in poor soils, but little manured, on which the system of fallows is still pursued, that the culture of rye is a profitable one; hence it is spread over Russia, Germany, and some parts of France, as abundantly as it is scarce in Britain. Rye-bread is still the staple nourishment of nearly one-third of the inhabitants of Europe.

It is less cultivated in the other parts of the globe, especially southwards.

3. Oats.

The oat *(Avena sativa)* is abundantly cultivated in Scotland, to the northernmost extremity of the island (58½°), in Norway to the 65°, in Sweden to 63½°; elsewhere, neither its northern nor southern limits are well ascertained.

Scotland is the only country in which oats constitute the habitual nourishment of man. The unleavened oaten cakes, which are made there resembling sea-biscuit, produce peculiar disorders, and are but poor food. In Scotland, the diffusion of civilization, formerly concentrated in certain points, the astonishing progress of industry and agriculture, and the ideas of *comfort* which its inhabitants acquire from England during their lucrative migrations, will, doubtless, cause them completely to abandon the use of oaten cakes for that of the potato and of wheaten bread.

4. Wheat, or Common Corn.

Common corn *(Triticum vulgare)* comprises an immense number of varieties, which have arisen from the cultivation of it during so many centuries. We shall now treat of the species in general, as comprehending those varieties called, from the seasons at which they are sown, *autumn* or *winter*, *spring* or *summer* wheat. Each of these varieties must have rather different limits, either to the north or to the south; but as neither travellers nor botanists, in alluding to these limits, commonly designate which variety is meant, I must follow their example.

Wheat is cultivated in Scotland, nearly to Inverness (58°); in Norway, as far as Drontheim (64°); in Sweden, to 62°; in Western Russia, to the environs of St. Petersburg (60¼°); in central Russia, it appears that the limit is between the 59° and 63° of latitude*. In America its extreme limit is not known, owing to the want of cultivators in the northern regions of Canada. Let us endeavour to determine the physical conditions of the limit in those countries where agriculture has pushed the cultivation of wheat as far as possible.

		MEAN TEMPERATURE, FAHR.		
	Degree of Lat.	Year.	Winter.	Summer.
		°	°	°
Scotland (Inverness)	58	46·3	36·5	57·3
Norway (Drontheim)	64	39·5	23·5	59·
Sweden†	62	39·5	23·5	59·
Western Russia (St. Petersb.)	60¼	38·	15·6	60·8

This table clearly shows that it is not owing to the cold of winter that this culture does not extend further north; and this fact would be still more evident if we had been able to trace the temperature of the limit further eastward: Moscow, for instance, is far within the limit of wheat cultivation, and yet its winter temperature is 10°·9. By sowing wheat in spring, it is withdrawn from the influence of winter, and when it is sown in autumn, it is protected during winter by a thick coat of snow. The further we advance northward, the thicker and most lasting does this efficient mantle become. The temperature of the air during the rigorous season cannot, then, exercise any direct influence on annual, or at least herbaceous, plants which are buried under the snow.

The mean temperature of the year, depending in part on that of winter, does not indicate more clearly what is suited to these same species; we accordingly see the annual mean vary nine degrees, if we include a small distance from the extreme limit of wheat in Europe.

On the contrary, the temperature of summer only varies 3°·5 on this same line; towards Russia, we find a higher temperature, 60°·8 on the limit, doubtless because the more intense cold of the winters produces a spring and autumn colder than in the west. It must follow, therefore, that in the centre of Russia, wherever the summer temperature is only 57°·4, which in the west suffices for wheat, the means of the preceding and ensuing months are not sufficiently high for it. In order to establish an accurate relation between a cultivation and a climate, it would be necessary to take the temperature of the number of days which elapses between the sowing and the harvest: but meteorological tables do not always allow of such calculations being made.

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[*] The data for these limits is obtained from the works of MM. Wahlenberg, *Schouw, and E. Meyer.*

[†] *From observations* made at Umea, Upsal, and Stockholm.

Without attaching much importance to those small variations which are sometimes due to inaccurate observations, it may be generally stated, 1. That the northern limits of cultivation of the Cerealia are almost parallel to each other. 2. That they nearly follow the inflexions of the *isotheral* lines, that is to say, of lines traced through the points, the mean *summer* temperature of which is the same.

The *isothermal* lines passing through those points which have the same *annual* temperature, deviates far from the isotheral lines, and consequently from the agricultural limits in question: the *isochimenal* lines passing through the points of the same winter temperature, deviate still more. These distinctions are by no means useless in northern regions, because, from about the 45°, the isothermal, isotheral, and isochimenal lines, are far from being parallel either to each other, or to the degrees of latitude. In the greatest part of Europe, the isotheral and isochimenal lines cut each other nearly at right angles[*].

In the north of America, the summer temperature of 57°·3, which appears to be the minimum indispensable to the cultivation of wheat, is found along a line which traverses the less populous parts of Canada: it starts from the southern point of Labrador, near Newfoundland (51°), from whence it passes between Hudson's Bay and Lakes Huron and Superior, under the 50° of latitude; further on it turns northward, so that in the middle of the continent, half-way between Hudson's Bay and the Pacific, it approaches the 58°. In confirmation of this it may be stated, that at Cumberland House (lat. 54° and long. 102° 40′ w.), the resident agents of the Hudson's Bay Company have established a successful cultivation. At that place, where the winter is excessively severe, Captain Franklin found fields of barley, wheat, and even maize (Indian corn). Westward, the line in question probably turns southward on approaching the Pacific Ocean.

What renders the northern limit of wheat an object of interest is, that it accidentally coincides in one part of its course with that of the fruit-trees whence cider is obtained, and in some points with the limit of the oak. The *ensemble* of the agriculture, and the aspect of the forests, therefore changes at once in a striking manner towards the *isotheral* line of 57·3°. The limit of the oak nearly coincides with an isothermal line (that of 39°·2), as might be expected of a tree exposed during winter to all the effects of atmospheric cold, as well as to the heats of summer. As to the limit of apple and pear trees, it conforms occasionally to an isotheral line, as ought to be the case, since in those places where the heat of summer does not allow of a harvest of fruit, plantations of orchards must be abandoned, otherwise, where the climate is very rigorous in winter, it is the cold which puts a limit to the cultivation of these same trees. In Scotland and Norway they are limited by the want of summer heat, and they there follow the *isotheral* line of 57°·3; in Russia, on the contrary, starting some leagues east of St. Petersburgh, the limit of fruit trees separates from that of wheat, and from the isotheral line of 57°·3, it inclines towards the south and approaches the isothermal line of 39°·2. It is no longer heat that is deficient, on the contrary, it is excessive; but the cold of winter freezes the trees, or else the rapid transition from cold to heat in spring, and the reverse in autumn, is contrary to the natural phases of vegetation.

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[*] *See Humboldt, Mem. d'Arc*, Vol. III., and the other works of the same learned *writer*, especially his *Fragmens Asiatiques*.

Wheat is cultivated, especially in temperate climates, between 36° and 46° of latitude; more northwards, rye is often preferred; southwards, new combinations of heat and moisture, and the addition of other cultures, sensibly diminish the importance of this precious cereal.

SPELT-WHEAT.

THIS species (*Triticum spelta*) is but little cultivated, except in Germany and some adjacent countries, such as eastern Switzerland.

The limits of its cultivation are not ascertained, its existence depending less on climate than on the habits of the population, and it is not, perhaps, desirable to extend it; the cultivation is also restricted by the peculiarity, that the fruit adheres so closely to the seed, that mills of a particular construction are requisite to thresh the ear before it is ground; this prevents the extension of the culture in those countries not provided with the necessary apparatus.

LIMITS OF THE CEREALIA ON MOUNTAINS.—It is scarcely necessary to observe that the Cerealia stop at different altitudes on mountains, preserving the same order they keep in the plains advancing towards the north. The following, according to M. Kastoffer, is their gradation in the Swiss mountains, and it is curious to observe the resemblance to the table of limits with respect to latitude:—

	In altitude.	In northern lat.
Wheat stops at	3400 Swiss feet	64°
Oats	3500	65°
Rye	4600	67°
Barley	4800	70°

It would be unreasonable to expect more accordance between observations made by different authors in distant countries on so delicate a subject. There may always be remarked, among some of the limits, a greater latitude than for the rest; in this case, there would probably be found a confirmation of the limits of summer temperature for each kind of grain, provided we could define the mean summer temperature at each altitude on the Alps; unfortunately, we do not possess thermometric observations, in different seasons for each altitude, sufficiently numerous to ground such refined calculations on. Moreover, it is not probable that the culture of the cerealia is carried up the mountains as far as it might be; the sterility of the soil, the inconvenience and difficulty of working lands lying on such a slope that the rains wash away the seed, the manure, and even the earth itself; are efficient causes for preventing the cultivation of mountainous districts. The proximity of deep valleys, and of plains in which agriculture would be more productive, must also contribute to deter the inhabitants of high regions from cultivating all the land which might be capable of cultivation.

Equatorial Limits of the Cerealia.—Extremes of heat arrest the cultivation of the Cerealia, especially that of wheat. This has been proved both by direct experiments instituted by several physiologists, and from observations in equatorial regions.

M. Theodore de Saussure[*] has proved that the seeds of different plants, especially of the common Cerealia, can support, even after germination has commenced, degrees of drought and heat far beyond those natural to the hottest climates. MM. Edwards and Colin[†] have shown that seeds of wheat, barley, rye, and oats, can germinate in a soil the temperature of which is as high as 104° or 113°, and to prevent germination entirely, the earth must attain and preserve a temperature of 116°—120°, which it hardly ever does in nature. It results from these experiments, that, of all the Graminaceæ cultivated in Europe, barley is that which ceases to germinate at the lowest temperature, just as it is the one which requires the least heat to germinate at all; next comes wheat, afterwards rye, and lastly maize. These facts are interesting in a physiological point of view, but they are more intimately connected with botanical geography; in fact, the elevated temperatures under consideration rarely occur in nature, especially at the depth at which seed is usually sown. But of what import is germination simply, if the climate is not adapted to the development of the stem, the flower, and to the ripening of the fruit? MM. Edwards and Colin having perceived this, made further experiments on this subject[‡].

They sowed Cerealia at Paris at different times of the year, and noticed at what mean degree of temperature each species or variety ceased to vegetate in a manner that would be advantageous in an agricultural point of view. They subsequently compared the results with the observations made in America by MM. Humboldt and Boussingault, as to the altitudes at which the culture of our Cerealia ceases. The analogy was found to be striking. It appears to me it would have been greater, and the comparison more instructive, if the authors had kept an account of the different seasons during which the Cerealia may be cultivated in intertropical countries, and if, in the Parisian experiments, the greater length of the days in summer than at the equator, the different division of the temperature during the twenty-four hours of the day, and some other particular circumstances, could have been obviated.

Barley, wheat, and rye, sown at Paris in the month of July, could not develop their stems, owing to the excess of heat: the mean temperature of this month is 71°·5. In the month of May, with a mean temperature of 65°, winter wheat did not flourish, but other Cerealia were able to develop themselves; hence MM. Edwards and Colin concluded that the Cerealia fail in furnishing a harvest when the mean temperature is nearly 64°·5, and some species, or varieties, when that temperature is as high as 71°·5 at most.

Now, according to MM. Edwards and Colin, M. Boussingault saw no cultivated cereal in the Andes which was not at an altitude of 1750 yards at least, that is to say, under a mean temperature of 66° at most. M. Humboldt's observations do not accord so well, apparently owing to the exceptions he points out. According to this author, the cultivation of the Cerealia ceases to prosper in America when the mean annual temperature is above 65° or 66°. In Mexico, they are nowhere cultivated on the table lands where the altitude is less than 850 or 950 yards. "Long experience," adds M. Humboldt, "has proved to the inhabitants of Xalapa, that wheat sown in the neighbourhood of that city vegetates vigorously, but that it does not form an ear; it is however cultivated, because its succulent culm and foliage furnish forage (*zacaté*) for cattle. It is nevertheless certain, that, in the kingdom of Guatemala, and consequently nearer the equator, wheat ripens at altitudes inferior to those of Xalapa. A particular exposure, the cool winds from the north, and other local causes, modify the influence of climate. I have seen in the province of Caraccas the finest wheat harvests near Victoria, (lat. 10° 3′, at 500 to 600 yards of altitude,) and it appears, the wheat fields surrounding Quatro-Villas in Cuba (lat. 21° 58′) are still lower*. In the Isle of France (S. lat. 20° 10′) wheat is cultivated on a district nearly level with the sea."

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[*] *Mém. de la Soci. de Physique et d'Histoire Nat. de Génève*, Vol. III. Part 2, p. 1. (1826); *Ann. des Sciences Nat.* Vol. X. p. 63.

[†] Annales des Sciences *Nat.*, Part I. p. 25 (1834).

[‡] Ann. des Sciences Nat. II. 5 Series, p. 1 (Jan. 1836).

The temperature of the Havannah in Cuba is 78°†, that of the Isle of France on the coast rises to 80° 3′. MM. Edwards and Colin do not mention these high temperatures, which appear as exceptions to their limits; they content themselves with stating, according to their experiments, that there are two limits of heat 65°—71°; "these," they say, "explain the exceptions mentioned by M. Humboldt;" but this is not sufficient to explain them, since the localities alluded to by M. de H. possess mean temperatures of from 77° to 80° 5′.

[To be continued.]

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* Elsewhere (*Tabl. Phys. des Régions Equat.*, p. 134) M. de H. speaks of fields of wheat in Cuba at an altitude of 150 yards.

† Humb. *Isoth. Lines*, last table.

A POPULAR COURSE OF GEOLOGY.

XIII.

UNSTRATIFIED ROCKS.—PRIMARY STRATA.—WERNER AND HUTTON.—FOSSILIFEROUS STRATA.—WILLIAM SMITH.

UNSTRATIFIED ROCKS.

THE unstratified rocks are Granite, Syenite, Greenstone, Hypersthene rock, Diallage rock, Serpentine, Basalt, Claystone, and Claystone-porphyry, Clinkstone, and Clinkstone-porphyry, Compact Felspar, and Felspar-porphyry,—Pitchstone, and Pitchstone-porphyry,—and the volcanic rocks, Trachytic, Basaltic, and Greystone Lavas, Obsidian, and Pumice.

GRANITE.

GRANITE is a compound crystalline rock. The minerals which enter into its composition are quartz, felspar, mica, and hornblende, united in variable proportions; but it is not essential that they should all be present. The rock usually denominated granite consists of quartz, felspar, and mica, with, occasionally, the addition of hornblende. Sometimes this mineral prevails to the exclusion of the mica, and the granite passes into a rock called syenite. By the prevalence of hornblende and felspar, it passes, in a similar manner, into greenstone. If mica and quartz predominate, it passes into mica slate, one of the non-fossiliferous stratified rocks. To all these compounds of two or more of the four minerals we have enumerated, many geologists, following the nomenclature of Dr. Mc Culloch, have applied the name of granite; but it cannot be used with propriety with respect to such rocks, unless where they are clearly subordinate to large masses of well-defined granite, and arise from accidental variations in the proportions of the ingredients, prevailing only over very limited spaces. Besides the four minerals above enumerated, others occasionally enter into the composition of granite. These are, chlorite, talc, actynolite, steatite, and compact felspar. But granites in which these form integrant parts of the mixture, are comparatively rare. Granite most commonly occurs in masses continuous over a great space, and having no determinate shape. These are frequently traversed by joints and fissures, which sometimes divide the rock into tabular masses, having the false appearance of stratification, sometimes give it a columnar structure, noticed at page 181. The texture is, as we have before observed, confusedly crystallized, the crystals interfering with one another's forms, and giving the rock a granular appearance. The magnitude of the parts is various; sometimes each particular mineral exceeds an inch in diameter, in other cases they are so minute as scarcely to be visible.

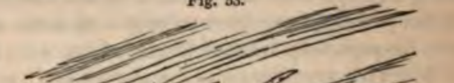
Graphic granite, which occurs chiefly in veins, consists of quartz and felspar alone, crystallized in prisms, the cross section of which gives rise to an appearance somewhat resembling Hebrew characters, whence its name.

Granite frequently assumes a porphyritic texture, that is to say, distinct crystals of felspar are imbedded in a granular base, of which felspar confusedly crystallized forms one of the ingredients. Examples of porphyritic granite from Cornwall are very abundant in the slabs with which the footpaths of the streets of London are paved. The colour of a rock consisting of several minerals blended in different proportions, and varying themselves in their colour, must of course be very variable.

The mineral which generally predominates, and determines the colour of the rock, is felspar, which is most commonly dark red or white; but it occasionally occurs of other hues, as ochre-yellow, pale and dark gray, and, rarely, green. Quartz, the most abundant ingredient next to felspar, is usually white or watery, sometimes gray, or nearly black, and has a large share in regulating the colour of the rock. An abundance of hornblende, which is always black or dark green, produces a rock varying from dark gray to black. The same effect is produced by mica when black; but as it is also white and brown, it occasions corresponding differences in the colour of the compound. It is almost needless, therefore, to add, respecting the colour of granite, that it is of various hues,—red, white, black, and gray,—the most common being white and dark red. Granite occurs as the fundamental rock on which all the other known rocks rest, though it is evident that the substances which afford the materials of the trap and volcanic rocks ejected to the surface are deeply seated below the granite.

Granite also occurs as beds of irregular shape, interposed among the strata of gneiss, and the other older stratified rocks. It is likewise met with in contact both with the ancient and modern strata in uplifted masses, which appear to have been consolidated before their elevation.

Fig. 53.



Another form in which granite occurs is as veins ramifying into the adjacent rocks, as in fig. 53, which represents the veins shooting from the granite through gneiss, at Cape Wrath, in Scotland; and they have been observed intersecting mica schist, clay stone, and limestone, in numerous other localities. Granite itself is frequently traversed by veins of granite of a different colour and mineral position; and there are instances near Heidelberg in which three sets of granite veins, of three different ages, all differing in colour, grain, and peculiarities of mineral composition, intersect each other. Dikes may be considered veins on a larger scale, the chief difference being, that dikes are of greater width, and have their sides parallel for greater distances; whereas veins branch out, and thin away into fine threads. Dike is the provincial name in the north of England for a wall, and is applied to large veins of igneous rocks, which traverse other rocks, because, being harder than *the rest of the* mass, they are less liable to decomposition, and project *in relief, having* the appearance of a wall. Granite is traversed by dikes as well as veins; and these have sometimes broken through the stratified rocks of different ages, and have covered them as irregular overlying masses. The most recent rock found in Europe into which granite has been observed to intrude, is a rock of the age of the chalk, in the hill of St. Martin, near St. Paul de Fenouillet, in the Pyrenees, described by M. Dufrénoy. Syenite, a rock closely allied to granite, has been found overlying the chalk at Weinbohla, near Meissen, by Professor Weiss, and by Mr. Griffith, at West Tor, near Fair Head, in the county of Antrim.

According to Mr. C. Darwin, the granite of the Cordilleras, in South America, has been in a fluid state since the tertiary era, and has altered and contorted strata of that age.

The origin of granite was a subject of much controversy within the last half century, between the followers of Werner and of Hutton, the former maintaining that it had been deposited from a state of aqueous solution, the latter that it had crystallized from a state of fusion. The igneous origin of granite is now generally admitted. The following are the proofs of this origin. It graduates in mineral composition through syenite and greenstone into basalt, and other rocks of the trap family, which are not to be distinguished from those rocks which we see poured forth from modern volcanoes; and the effects produced by granite and the trap rocks on the sedimentary strata with which they come in contact are precisely the same as those produced, under similar circumstances, by the volcanic rocks. Among others they convert beds of coal traversed by them into coke and anthracite; and in the same manner that beds of lava are traversed by dikes and veins of more recent lava, so is granite traversed by dikes and veins of granite more recent than itself. Additional proofs of the igneous origin of some of those trap rocks into which granite passes by insensible gradation, were furnished by the experiments of Mr. Gregory Watt and Sir James Hall. The former, on fusing basalt, found, that if suddenly cooled, it formed a vitreous mass, but if allowed to cool slowly, it returned to its original stony character and prismatic structure. Sir James Hall produced artificial crystalline rocks by submitting their pounded ingredients to strong heat under pressure.

Professor Mitscherlich, as we have before observed, formed artificial crystals of augite, which is closely allied to hornblende, one of the constituents of granite, by the fusion of definite proportions of the earths which enter into its composition; and though all efforts to produce artificial crystals of felspar have hitherto failed, they have been found on the walls of a furnace in which copper slate and copper ore had been smelted.

SYENITE.

THIS rock consists of compact or crystallized felspar, united with hornblende and quartz. The name is derived from Syene, in Upper Egypt, where it abounds. It occurs in overlying masses and dikes.

GREENSTONE.

THE components of greenstone are compact or crystallized (sometimes *vitreous*) felspar, and hornblende or augite, the texture varying from largely granular to almost earthy. When the felspar is crystallized it is not easy to distinguish greenstone from syenite. Most writers make the difference between these rocks to consist in colour, giving the name of syenite to those compounds which are red and pale, white and yellow, and that of greenstone to those which are gray or greenish. The two colours may frequently be seen in the same block and even hand specimen. Ingenious advantage has been taken of this transition from greenstone to syenite in the formation of a colossal Egyptian statue in the British Museum, the body of which is greenstone, and the head (part of the same block) is composed of red felspar, through which crystals of hornblende are dispersed.

A better distinction than that derived from the colour of the felspar appears to be founded on the proportions of the ingredients; those in which the felspar prevails being classed as syenites, and those in which the hornblende, or augite, predominates, as greenstones. The compounds of common felspar and augite are called augitic greenstones.

The augite rock of Dr. M'Culloch consists of compact felspar and augite greenstone; sometimes contains cavities filled with almond-shaped nodules of agate, calcedony, or carbonate of lime. These varieties are termed amygdaloid. Greenstone occurs in dikes, and in interposed and overlying masses, and has frequently a columnar structure.

HYPERSTHENE ROCK.

THE felspar is compact or crystallized, generally common, but sometimes vitreous, of a white or red colour. It occurs sometimes in dikes, but more commonly in uplifted masses associated with granite.

SERPENTINE AND DIALLAGE ROCK.

BOTH common and noble serpentine are considered when pure as simple minerals, and in that state form considerable masses, but they are generally more or less mixed with diallage. Diallage rock consists of diallage and compact felspar. Both these rocks occur blended with greenstone, into which they gradually pass. The varieties of serpentine enumerated by Dr. M'Culloch, are—

1. Common Serpentine.

1. With an earthy and uniform fracture.——2. With a splintery fracture passing into conchoidal.——3. With a splintering fracture passing into granular.——4. With a granular fracture, softer, and becoming sectile, the potstone of some mineralogists.——5. Passing into indurated talc a variety of talcose schist, the potstone of others.

2. Noble Serpentine, with a foliated and splintering fracture, conchoidal or splintering conchoidal. They occur in dikes and masses, also interposed among the primary strata, resembling the irregular beds of limestone occurring in similar situations, also in overlying masses. Instances are mentioned by Dr. M'Culloch, in which dikes of greenstone passing through limestone change into serpentine when they come in contact with the limestone.

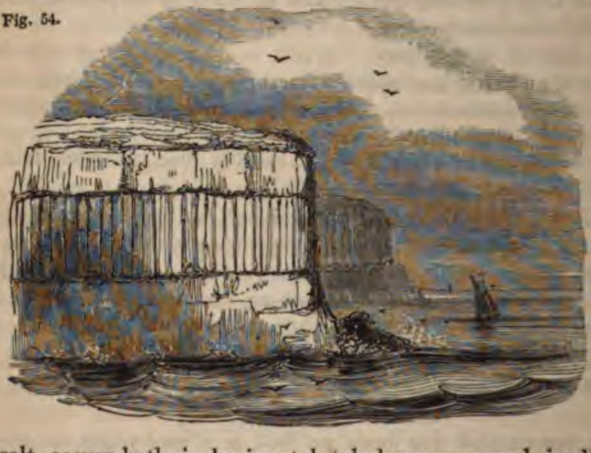
BASALT.

THIS is a term which has been applied in a very vague manner. Any dark-coloured rock having a columnar structure was for a long time called basalt; thus columnar claystone, clinkstone, compact felspar, and greenstone, were all *confounded* under this name, or the still more indefinite term, *trap*. *The latter* word is derived from the miners of Sweden, in *the language of which* country *trappa* signifies a step or stair, and was applied to these rocks on account of their occurrence in large tabular masses, rising one above another like a flight of stairs. The columnar structure has long been abandoned as a distinctive character of basalt, and the term is now limited to a dense compact mass of hornblende or augite, in which crystals of felspar are visible, and containing titaniferous iron. As the felspar increases in quantity, and the hornblende or augite becomes coarser grained, it passes into greenstone; those basalts which are composed of augite and felspar, are sometimes called dolerites.

The aqueous origin of basalt was as fiercely maintained by the Wernerians as that of granite. It was in fact the weakest point of their position; for let basalt be admitted to be an igneous rock, and it was difficult, if not impossible, to ascribe an aqueous origin to the varieties of greenstone and syenite through which it passes by insensible gradations into granite.

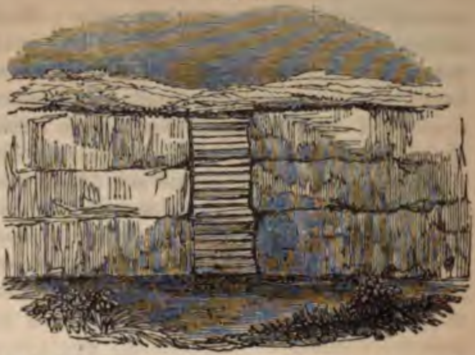
Basalt is now admitted to be a pyrogenous rock by all geologists, even by those who, in the early part of their career, were most deeply imbued with the Wernerian doctrines. It is scarcely thirty years since Dr. Buckland and Mr. Conybeare went to the county of Antrim to collect proofs of the aqueous origin of basalt, and they came back proclaiming it to be an igneous rock. They saw the changes produced by it on the sedimentary rocks. They saw chalk converted at the point of contact into crystalline limestone, in the same manner that in the experiments of Sir James Hall powdered oyster-shells were converted into marble by heat under pressure; they saw coal converted by it into coke and cinders, and they were convinced. The igneous origin of basalt was never questioned by those geologists who had opportunities of studying nature in countries which are the seats of active volcanoes. The varieties of lava termed augitic are not, in point of fact, to be distinguished from augitic basalt.

Fig. 54.



Basalt occurs both in horizontal tabular masses and in dikes, and both in dikes and masses exhibits the columnar, globular, vesicular, and amygdaloidal structure. When basaltic columns occur in tabular masses, they are usually vertical, as in fig. 54. In dikes they are smaller, and arranged horizontally, as in fig. 55, and are generally termed prisms.

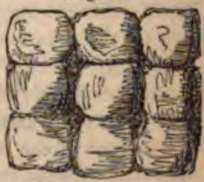
Fig. 55.



The globular structure is often visible in the decomposition of basaltic and volcanic rocks, and in a solid rock, called the orbicular granite of Corsica, in which balls or spheroids are disseminated through the rock, and consist of concentric alternating layers of hornblende and compact felspar.

From some experiments of Mr. G. Watt, it appears that the columnar structure of basalt arises from the pressure of numerous spheroids on each other during the process of cooling. He fused seven hundred weight of fine-grained amorphous basalt, maintaining the fire for six hours, and allowing it to cool so slowly that eight days elapsed before it was removed from the furnace. The mass was then four feet and a half long, two feet and a half wide, eighteen inches thick at one end, and four at the other; an irregularity of form highly favourable to the exhibition of the different kinds of structure arising from different rates of cooling. Where the mass was thin it was vitreous; where, owing to the thickness, the cooling had been more gradual, it was stony, and there were parts exhibiting a transition from one state to the other. Numerous spheroids, sometimes two inches in diameter, had been formed, radiated with distinct fibres, and which also formed concentric coats, where circumstances had favoured such an arrangement. In other parts, where the temperature had been sufficiently kept up, the centres of the spheroids became compact before they attained the diameter of half an inch. When two of these spheroids came in contact, they did not penetrate each other, but were mutually compressed (fig. 56), and separated by a well-defined plane invested with a rusty coating; and where several met they formed prisms.

Fig. 56.



Some basalts are vesicular, and contain small hollows caused by bubbles of gas or vapour, while the rock was in a fused state. These cavities have often been filled by infiltration with nodules of carbonate of lime, agates, zeolite, and other minerals. As these nodules have, in general, an elongated shape, resembling an almond, such basalts have received the name of amygdaloidal. Basalt possesses this vesicular and amygdaloidal structure, as well as the columnar, in common with lava. When, as is frequently the case, several alternations are observed in the same tabular mass of basalt, these appearances would seem to indicate that it was not produced by one, but by several ejections of fused matter, which assumed different characters, according to the different circumstances under which they burst forth. Basaltic rocks are of very general distribution, being found in the neighbourhood of most active or extinct volcanoes, as well as in situations where it would appear that there had been no volcanic cone or crater, but that the melted matter had forced its way through fissures beneath the bed of the ocean, and had thus flowed over other rocks. The largest known area occupied by basalt, is in the Deccan, as described by Colonel Sykes, where it covers many thousand square miles of surface. The chief British localities for basalt, are the north of Ireland, where it occupies a large portion of the country of Antrim; in Scotland, near Edinburgh, and in some of the Hebrides; in the north of England, near Teesdale, in Yorkshire, in the counties of Northumberland and Durham, and in the Clee Hills in Shropshire. The great Cleveland dike, which ranges through parts of the counties of York and Durham, may be traced for nearly seventy miles. The finest instances of the columnar structure in basalt, occur in Fingal's Cave, in Staffa, one of the Hebrides, and at the Giant's Causeway, and at Fair Head, in the county of Antrim.

PORPHYRY.

THE name is derived from a Greek word, signifying purple,—the porphyry used by the ancients for ornamental purposes, being of that colour. The term is now applied to any rock having a compact base, in which distinct crystals are imbedded. The base is generally compact felspar, or its allied rocks, clinkstone and claystone. The imbedded crystals are either quartz or felspar, most commonly the latter, and these felspathic crystals are sometimes common, sometimes vitreous felspar. Porphyry has become so vague a term, as to convey no idea of the composition of a rock to which it is applied, unless associated with the name of the base. Thus we have claystone porphyry, clinkstone porphyry, felspar porphyry, and pitchstone porphyry. Each of these bases occur under various modifications of colour; and the diversity of aspects thereby occasioned, is still further increased by the various colours of the imbedded crystals, their different sizes and modes of aggregation, among which, the crossing of the crystals is the most worthy of notice. These porphyries pass into simple rocks, by the gradual diminution of the number of their imbedded crystals; and since both the simple and compound rocks are frequently found in the same mass, hand specimens do not always represent the nature of the rock. The bases of these varieties of porphyry have been described under the simple minerals bearing the name of claystone, compact felspar, and clinkstone, in our last number.

Felspar porphyry is by far the most common; it occurs both in overlying and interposed masses, sometimes having a columnar structure, and also in dikes traversing the strata. The British localities are North Wales, Glencoe, Ben Nevis, Ben Cruachan, and other parts of the Highlands of Scotland, the Island of Arran, Cumberland, Cornwall, and various parts of Ireland.

Pitchstone is a glassy felspathic rock having a great resemblance to pitch; it occurs in interposed beds and dikes traversing granite, secondary sandstone, and traps. It has sometimes a prismatic structure, sometimes occurs in curved lamellar concretions. Its structure is frequently porphyritic. The imbedded crystals are sometimes rounded, and converted into a gray or white enamel on the exterior, the smaller crystals being replaced by spheroidal grains, consisting entirely of the same enamel. This variety passes into pearlstone. Pitchstone likewise graduates into calcedony and chert, and into obsidian, a decided volcanic product. Dr. M'Culloch has observed a transition from basalt into pitchstone, on the outside of dikes of basalt, and also when they ramify into slender threads; and similar transitions from lava to pitchstone in the walls of dikes of lava on Somma, have been noticed by M. Necker and Mr. Lyell; a circumstance which is easily accounted for, from the more rapid cooling which would take place in such situations, than in the interior of the mass, and which the experiment of Mr. Watt, before alluded to, showed to be favourable to the production of the vitreous state. The British localities for pitchstone, are the Isle of Arran, and the Scuir of Egg.

VOLCANIC ROCKS.

We have already, under the head of basalt, alluded to the principal difference between the trap rocks and the products of active volcanoes, as consisting, in a greater degree of compactness in the traps, and in the prevalence of augite instead of hornblende in the lavas. The classification of lavas into trachytic and basaltic, is that most commonly adopted. Mr. Scrope has added a third division, to which, from its colour, he has given the name of graystone; but volcanic products are of such a compound nature, that it is extremely difficult to assign them names. The following is Mr. Scrope's arrangement.

TRACHYTIC LAVAS.

Simple Trachyte.—Compact felspar, with crystals of vitreous felspar.

Compound Trachyte, with mica, hornblende, or augite, and grains of titaniferous iron.

Quartziferous Trachyte, with crystals of quartz.

Siliceous Trachyte.—When siliceous earth appears to enter largely into its composition.

GRAYSTONE LAVAS.

Common Graystone.—Felspar, augite, hornblende, and iron.

Leucitic Graystone.—Leucite supplies the place of felspar.

Melilitic Graystone.—Melilite replaces the felspar.

BASALTIC LAVAS.

Common Basalt.—Composed of felspar, augite, and iron.

Leucitic Basalt.—Leucitic replaces the felspar.

Olivine Basalt.—Olivine replaces the felspar.

Haügine Basalt.—Haügine replaces the felspar.

Ferruginous Basalt.—Iron is the predominant ingredient.

Augitic Basalt.—The rock almost wholly composed of augite.

Many subaërial volcanoes have ejected trachyte and basaltic lava, but most of the basaltic rocks have been formed under the pressure of the sea, or of other strata, and have been subsequently elevated to the surface. This is the reason of their being more compact than subaërial lavas.

The following may also be mentioned as volcanic products:—Obsidian, a vitreous lava, being the result, no doubt, of rapid cooling, having a black colour in mass, but translucent in thin fragments.

In defending the aqueous origin of the unstratified rocks, the Wernerians were driven to deny, that this rock had ever been in a state of fusion; which was as rational as it would have been to have contended that bottle-glass had been formed as a chemical deposit from a state of aqueous solution.

Pumice is a light, spongy lava, of a white colour, produced, most probably, by the access of gases or steam, to lava, in a state of fusion. It may be considered as the froth of lava. Transitions are observable in the same mass, from obsidian into pumice.

Volcanoes also eject from their craters, besides currents of lava, vast quantities of dust, ashes, and stones, which being blown vertically into the air by the explosive force of gases and vapours, and falling round the sides of the vent, produce conical hills of a loose material. Similar materials, swept down by the torrents caused by heavy rains, and the melting of the snows, which frequently accompany these eruptions, give rise to streams of volcanic mud, or, as they are called, aqueous lavas, which, as they consolidate, form rocks of an earthy appearance, known by the name of volcanic tuff or tufa. Similar tuffs are produced when these light ashes and scoriæ fall into lakes and hollows. The same kind of ejections of fragmentary matter must take place from the craters of submarine volcanoes, though the conditions under which they occur, do not permit us to observe them.

The Island of Sciacca, or Graham's Island, which recently arose, and disappeared in the Mediterranean, consisted principally of loose scoriæ, which being dispersed by the waves, and agitated in the sea, would be spread over its bed, and form volcanic tuff, or sandstone, containing, most probably, organic remains.

In taking a general review of the unstratified rocks, we cannot fail to remark such a striking similarity among them, in composition, structure, and mode of association with other rocks, as to induce us to regard them as members of one family; as parts of a great mass of melted matter poured out, at different times, from the interior of the earth, and differently modified, according to the circumstances under which the ejections took place. Hornblende, or augite, and felspar, either compact, crystallized, common, or vitreous, enter into the composition of them all. They possess a crystalline texture, and affect, for the most part, a columnar structure. They all occur as intrusive beds, veins, or dikes, or as overlying masses, the connexion of which with a dike may often be clearly traced. We know that the different members of the group pass into each other, by insensible gradations; so that two or more of them may be found in the same dike, or mass, and that they graduate, in like manner, into undoubted volcanic products. We also know, by experiment, that when melted, the resumption of the stony character takes place, under circumstances favourable to gradual refrigeration, and that some of their constituent minerals have been formed artificially, in the crucible of the chemist.

If we examine the difference between the various members of the group, it becomes apparent that, taking the granitic rocks as a whole, they are distinguished by the prevalence of quartz, in crystals or concretions, and by the abundance of mica; and that in the trappean or basaltic rocks, mica diminishes in quantity, while hornblende considerably increases, and that augite and vitreous felspar prevail in the modern lavas. The greater prevalence of the basaltic rocks over the granitic, among the more modern formations, is also to be noticed. The difference between lava and basalt is precisely what might be expected between subaërial and submarine ejectments. What the peculiar modifying circumstances were which caused the formation of the granitic rocks so exensively during the earlier epochs of the world we know not; extreme slowness of cooling, and very great pressure, not only from a deep ocean, but from superincumbent strata, may have been among these causes; but, whatever they were, it would seem, from the rocks of different ages which have been penetrated by the granite, that those circumstances have recurred at intervals, though far more rarely, during the more modern epochs, when those conditions prevailed which were favourable to the production of the basaltic rocks.

In the Wernerian system, granite and the other unstratified rocks were treated as aqueous productions; volcanoes, which in modern times add so largely to the rocky mass of the earth's surface, were considered phenomena of recent date, quite unknown in the primæval ages of the world. The reason of this was, that Werner, who, in 1775, was appointed Professor of Mineralogy in the Mining School of Freyberg, in Saxony, had studied geology, or, as he called it, geognosy, in a country far removed from any active volcano, and he had not extended his observations beyond his own immediate neighbourhood. He had great merit in directing the attention of his pupils to the natural position of minerals in certain rocks, and to the constant relations of superposition that prevail among them; in the enthusiasm with which the charms of his eloquence and his manners inspired his hearers, and in the impetus thereby communicated to the study of geology; but his system contained this radical defect, that his generalizations were founded on too limited an induction.

> Urbem quem dicant Romani Melibœe putavi
> Stultus ego huic nostræ similem,

is a confession which might often be made by philosophers as well as peasants, if they had equal shrewdness with Tityrus in discerning their errors, and equal candour in acknowledging them; and by none could it have been uttered with more propriety than by Werner. He had framed a theory of the earth, which was made to accommodate itself, in its minutest details, to the phenomena observable in his own valley, and to no others; and such was the veneration in which he was held by his followers, that to doubt of the existence of one of his universal formations, even the most problematical, was looked upon as a pestilent philosophic heresy; and there were many of his disciples who spent their lives in observing nature only to misinterpret her language, and to torture it into accordance with the dogmas of their oracle, and with the nomenclature and classification of his "geognosy."

STRATIFIED ROCKS.—THE PRIMARY OR NON-FOSSILIFEROUS STRATA.

We proceed now to the consideration of the stratified rocks. These form a series, the total depth of which has been estimated at nine miles. About one-fourth of this may be assigned to the lower part of it, which is destitute of organic remains; some of its members, which, taken as a mass, are the lowest, being intimately connected in composition with some of the unstratified rocks to which, on the evidence already adduced, an igneous origin has been attributed. To the non-fossiliferous strata, no classification can be applied that is not based on their mineral characters. The remainder of the stratified series can only be regarded mineralogically as a succession of clays, sandstones, and limestones, alternating in no fixed order, as far as regards their mineral composition, and changing that composition in the same horizontal plane, but capable of being divided into groups, characterized over very extensive areas by peculiar assemblages of organic remains. The classification of them must, therefore, be founded on their zoological characters.

The first attempt at a methodical arrangement of rocks was made by Lehman, in 1759, who divided them into *primitive* and *secondary*. The primitive were those which contained organic remains, or fragments of other rocks, and which he supposed were formed with the world, and before the creation of animals. The secondary were the fossiliferous strata, which he supposed to have resulted from the partial destruction of the primitive rocks by a general revolution. Out of these, Werner formed a third class, which he named *transition*, from having observed that between the primary rocks and those in which the characters of the secondary class were most strikingly developed, there existed an intermediate group, containing few organic remains, and approaching the crystalline character of the primary rather than the fragmentary character of the secondary rocks.

To the remainder of the secondary strata, out of which this class was taken, he gave the name of *Floetz*, or horizontal, from an erroneous belief, founded on the observation of a limited district, that rocks of this class were stratified only in horizontal planes, which is true only of low-lying regions; for on the flanks of the Alps and Pyrenees the horizontal rocks of Werner are found as highly inclined as any of the primitive. His floetz rocks terminated in the ascending order with the chalk, and as the investigations of Cuvier and Brogniart brought to light some strata above the chalk, important on account of their zoological relations, which were so different from those of the secondary class, the followers of Werner were compelled to subdivide their floetz rocks into older and newer floetz, comprising under the latter name those formations which, by other writers, were called Tertiary.

Mr. Conybeare proposed, in the year 1822, an entirely new nomenclature for these general divisions, without reference to hypothesis, and founded entirely on their undoubted relative position. Taking the carboniferous series,—a group well defined by mineral characters, all over Europe at least,—as his point of departure, and including in it the mountain limestone, to which he gave the name of the carboniferous, he called this group the medial order, from its position near the middle of the series. The transition and primitive rocks of Werner he called the *inferior order*. The *supermedial order* extended from the coal measures to the chalk, which it included; and under the name of the *superior order*, he classed all the regular tertiary strata that were then known.

There is, however, so much inconvenience in changing established scientific names, and the disadvantages so nearly counterbalance the advantages, unless the change be made with the concurrence of the cultivators of science in all countries, that there is always a repugnance to innovation in matters of this kind; and in other sciences, besides geology, objectionable names are retained in current use in preference to others that would be more appropriate. The system of Mr. Conybeare, therefore, never established itself as a part of geological nomenclature. The only change he succeeded in introducing was the substitution of the name of carboniferous limestone for that of *mountain*, or *transition*, or *encrinitic* limestone, which it had previously borne.

No better success attended an attempt made about the year 1830 by Mr. De la Beche, to abolish the terms Primary, Transition, Secondary, and Tertiary, and to divide the rocks constituting the earth's crust into the two natural sections of stratified and unstratified, and to subdivide the fossiliferous series into the nine following groups, taking them in the descending order:—1. The *modern*, or formations now in progress; 2. The *erratic block* group, a provisional group, containing transported boulders and blocks, and gravels on hills and plains, apparently produced by greater forces than those now in action; 3. The *supracretaceous* group, the tertiary strata of other authors; 4. The *cretaceous* group; 5. The *oölitic* group; 6. The *new red sandstone* group; 7. The *carboniferous* group; 8. The *grauwacké* group, or upper part of the transition class of Werner, since named by Mr. Murchison, the Silurian system; 9. The *lowest fossiliferous* group, answering to the lower part of the transition class, since named by Professor Sedgwick, the Cambrian system.

The classification and nomenclature of Werner, however, with some modifications, continued in use, partly on account of its convenience, and from that repugnance to change to which we have before alluded; and partly from a feeling that we were not yet in possession of sufficient data to be able to frame a systematic nomenclature of the stratified rocks. Since, then, any new classification could be considered only as provisional, it seemed a matter of comparative indifference which of two imperfect systems was adopted.

Geologists, therefore, continued to speak of primary, transition, and secondary rocks, merely as a convenient mode of designating certain groups of strata, without supposing that these divisions had any foundation in nature, and without reference to the sense in which those names were originally imposed.

It had, however, long been evident that the name of transition must be abandoned, on account of the indefinite manner in which it had been applied, some geologists limiting it to those older rocks which were supposed to contain the earliest traces of organic remains, others including in it the whole of the carboniferous series.

The term fossiliferous grauwacke, which it was proposed to substitute for it, was liable to equal objections, because, having been originally applied to a rock of a certain mineral character, it must, if used in the proposed new sense, have comprehended a variety of rocks of very different composition; an ambiguity of expression that would have led to much confusion.

The researches of Mr. Murchison among the rocks of the Welsh border, and of Professor Sedgwick among the slate rocks of Wales and

Cumberland, not only placed in a still stronger light the necessity of some new and precise mode of designating the rocks below the old red sandstone, but furnished us with the means of dividing them into several important groups, and thus reducing into something like order, a great assemblage of beds, which, not in England only, but in Scotland, Ireland, Germany, Prussia, Sweden, and North America, were, till recently, involved in the greatest obscurity and confusion.

From the upper part of the series, below the old red sandstone, Mr. Murchison has separated a system of rocks, which, in the counties bordering on Wales, is so largely developed as to comprise a total thickness of 7,500 feet, divisible into formations by separate and peculiar groups of organic remains. To this system he gave the name of the Silurian, from the Silures, one of the principal tribes of the ancient Britons, who inhabited the district in which this system of rocks was first observed, and is most extensively developed. These rocks he has further subdivided into the upper and lower Silurian, each subdivision comprehending two formations. These rest, in some cases conformably, in others unconformably, on another great system, in which traces of organic remains occur, and which are distinguished in Wales and Cumberland by a subcrystalline and concretionary structure, and by having a slaty cleavage, that is, being capable of indefinite subdivision in planes transverse to those of the stratification.

This system, Professor Sedgwick, whose researches are as yet only partially published, has named the Cambrian, from the country in which it occurs extensively developed, in juxta-position and conterminous with the Silurian, which it succeeds in the descending order; and he has subdivided it into the upper, middle, and lower Cambrian. The names of the Silurian and Cambrian systems, and of the subdivisions of the former, have been adopted with the advice and concurrence of all the leading geologists and scientific bodies, both English and foreign, and may, therefore, be considered as established. The Cambrian system is capable of being divided into several distinct formations; but, from the paucity of organic remains contained in it, none of which have as yet been specifically determined, and from other difficulties, the attempt to subdivide it appears at present premature. The lower Cambrian formation of Professor Sedgwick occupies a small portion of the south-west of Caernarvonshire and much of Anglesea. In neither of these districts have any organic remains been detected in it. In Anglesea it has been described by Professor Henslow as chlorite schist, graduating sometimes into mica schist, under which head, he says, it would be classed by most geologists.

Abandoning, then, the terms transition and grauwacke series, we shall divide the stratified rocks into primary, lower secondary, upper secondary, tertiary, and modern. The primary will be limited to the non-fossiliferous strata. The lower secondary will commence with the oldest formation in which organic remains are found, that is, at present, the middle Cambrian of Professor Sedgwick, and will include, in the ascending order, the carboniferous system. The upper secondary will commence with the new red sandstone, saliferous, or poikilitic system, and will terminate with the chalk. The tertiary will comprise all those regular deposits above the chalk in which existing species begin to appear, mixed with others that are extinct, and which Mr. Lyell has divided, according to the percentage of shells of existing species contained in them, into the eocene, miocene, and older and newer pliocene strata. The term modern will be confined to those formations which contain human remains, or those of existing species of animals unmixed with others that are extinct.

With respect to that portion of the loose covering of the earth, to which we have before alluded, and which Mr. De la Beche refers to an erratic block period, the marine remains found in it, within the British islands, at various heights, and in numerous localities, have hitherto all been of existing species, and on that evidence it should be classed with the modern formations. Most of the remains of mammalia contained in it belong to extinct species, or to species no longer inhabiting Europe. But while we believe in the existence of a period intermediate between the close of the tertiary era and the commencement of the present order of things, characterized by the passage of a large body of water from north to south over a great part of the northern hemisphere, there are others who consider these phenomena as the effects of causes now in action, and acting with the same intensity as now. According to them, this transport took place before a large portion of England had emerged from the sea, and the blocks were floated upon ice. The evidence on the subject is far from complete, but the first cavern containing the remains of mammalia which shall be found within the region of this northern drift, and covered by it, will settle the question.

PRIMARY, OR NON-FOSSILIFEROUS STRATIFIED ROCKS.

The primary strata are gneiss, mica schist, hornblende schist, chlorite schist, talcose schist, quartz rock, primary limestone, and argillaceous schist.

Gneiss.

Gneiss may be called slaty granite. It is composed of the same ingredients as that rock, viz. quartz, felspar, mica, and hornblende, united in various proportions, with the occasional absence of one or other of them, and the presence of a few other minerals. The distinctive character of gneiss consists in some of its component minerals, generally the mica and hornblende, being arranged in layers parallel to the stratification, so as to impart to the rock a foliated appearance, or to give it a schistose character, sometimes so perfect as to admit of its being cleaved for economical purposes. This character becomes less perfect when the gneiss is in contact with granite, or traversed by veins of it, and, at the point of contact, disappears entirely, so that the two rocks cannot, at their junction, be distinguished from one another. Fine-grained gneiss passes by the disappearance of felspar into mica schist; by the prevalence of quartz into quartz rock, and of hornblende into hornblende schist. The stratification of gneiss is irregular and contorted, the dimensions of the strata variable. Where the rock occurs in large masses, they are thick; when they alternate frequently with others, they are thin. When they are not separated by such alternations, the distinction between the several beds is formed by a change in the proportions of the ingredients. Gneiss is, in many countries, the most abundant of the primary strata, occurring in large masses, which occupy extensive districts, and form lofty mountains, without any other alternating rock. In such cases it reposes upon granite, and is succeeded by the other primary strata, but in some cases succeeds one or other of these, the series alternating in large masses.

There are other instances in which a large series of strata, consisting principally of gneiss, contain alternating strata of other rocks in inferior proportions. The most common of these is hornblende schist; mica schist and quartz rock are next in abundance; argillaceous schist is more rare. Strata of gneiss are often invaded by veins of granite, which are not always transverse to the stratification, but sometimes run parallel with it, assuming for short spaces the stratified appearance of gneiss, and, when of large dimensions, are liable, without very careful observation, to be mistaken for stratified granite.

The British localities for this rock are the Western Isles and north-west Highlands of Scotland.

MICA SCHIST.

MICA SCHIST is a confusedly crystalline compound of quartz and mica, united in different proportions. It has a foliated or laminar texture, and is more or less fissile according to the proportion and mode of disposition in which the mica enters into its composition. It is sometimes capable of being separated into coarse slates; sometimes the laminar fracture is very irregular and imperfect. There are cases in which it approaches a granular texture; but when the quartz wears the most granular appearance, it is always united by a crystalline cement of that mineral.

Beds of mica schist are sometimes affected by large contortions, but there are many cases in which, when the contortions are minute and intricate, they seem only to involve the laminæ without extending to the bed itself.

The stratification of mica schist, when occurring, as is frequently the case, in large masses, occupying great tracts of country, is very difficult of detection. When the beds are not separated by alternating rocks, they are distinguishable, like those of gneiss, by changes in the proportions of their component parts. By the admission of felspar it graduates into gneiss; and by the preponderance of the quartz, into quartz rock, with which it occurs extensively associated. The colour of the different varieties of mica schist depends upon the quantity of mica which they contain, which varies in hue from white to black, the quartz being almost invariably colourless. The prevailing colour of the rock is therefore gray, except when passing into chlorite schist, when it becomes green.

Mica schist differs from gneiss in not being traversed so much by veins of granite. These only occur in it when in contact with the granite, the veins being small, extending only a short distance from the mass, and their origin being easily traced; but it is subject to be much penetrated by veins of quartz, both transverse and parallel to the laminæ of stratification, and when these are contorted, the veins are contorted also.

Mica schist, like gneiss, forms extensive tracts of country and lofty mountains, but it also occurs in beds of a few feet in thickness, associated and alternating with gneiss and quartz rock.

The British localities are the Scotch Highlands and the north-west of Ireland.

CHLORITE SCHIST.

THE essential ingredients of this rock are chlorite and quartz, occasionally mixed with felspar and hornblende. It may be distinguished from mica schist by its green colour and saponaceous feel. Its most extensive association is with mica schist, into which it passes in so insensible a manner, by the gradual mixture of the two minerals with quartz, that it is often difficult to decide which name to assign to the rock. It is under such circumstances that it forms masses of the greatest extent. It likewise occurs largely associated with argillaceous schist, into which it passes by a transition more or less perfect. It alternates in smaller strata with gneiss, and by the addition of felspar graduates into some of the chloritic varieties of that rock.

Chlorite schist, under a great variety of aspects, occupies, as we have before observed, a large portion of the Isle of Anglesea, and a small patch of it is found at the south-west extremity of Caernarvonshire.

TALCOSE SLATE.

THIS rock is composed of talc alone, or of talc and quartz. It resembles the two preceding rocks, but is distinguished from them by the peculiar characters of the talc, and by its colours, which are lead-gray, white, and obscure green. It occurs only in beds of very limited thickness and persistency, imbedded in gneiss, mica schist, and chlorite schist, and in a few rare instances, in argillaceous schist, into all of which it gradually passes.

HORNBLENDE SCHIST.

UNDER this term Dr. M'Culloch proposed to include all those compounds previously known by the names of hornblende rock, primitive greenstone, and greenstone-slate, whether possessing a schistose structure or not, which are clearly contemporaneous with the strata among which they occur. Its ingredients are hornblende and felspar, but the hornblende sometimes prevails to the exclusion of all other minerals. It occurs alternating with gneiss. It is rarely met with in large masses so as to form extensive tracts, without the alternation of other rocks. It is most frequently associated with gneiss, and less commonly with mica schist. When associated with argillaceous schist, it is occasionally observed to pass insensibly into that rock.

QUARTZ ROCK.

THIS is a stratified rock, the beds of which vary in dimensions, the distinctions between them being more strongly marked than those of gneiss and mica schist, with which it is often associated. It is divided by natural *joints, which* cause it to break into rhomboidal or rectangular *fragments. The* variations in its mineral character are numerous; its most simple form is thus described by Dr. M'Culloch:—"It is occasionally, but rarely, found in a compact state and crystalline throughout, little differing from quartz, as it occurs in veins, but even in those cases showing a constant tendency to divide in parallel beds. More frequently, when pure, it has an aspect obscurely granular, which by degrees becomes somewhat lax and arenaceous, the grains varying in size and in the intimacy of their union. In some of these examples it appears to be a granular crystalline mass; in others it possesses a mixed mechanical texture, while in a third, the rounded aspect of the grains, and the small number of points of contact, appear to indicate an origin chiefly mechanical, and resulting from the agglutination of sand. Cavities are sometimes found in the specimens containing regular, though minute crystals of quartz*."

There are other varieties, consisting of quartz intermixed with felspar, and quartz intermixed with mica, forming the passage into gneiss and mica schist, with both of which rocks it alternates, as also with argillaceous schist. The colour of quartz rock, when pure, is white, but it occurs of other shades, as ochre-yellow, and red. The presence of mica often produces a gray-coloured rock, and a mixture of felspar communicates a flesh-red tint to this compound form of quartz rock.

Argillaceous Schist.

This is a schistose rock, consisting chiefly of indurated clay, varying in hardness, fissility, and composition, and undistinguishable, except by position, from the argillaceous slates of the lower secondary series. Its essential minerals are the indurated clay which forms the whole of the simple varieties, and quartz and mica, which enter into the compound varieties. The prevalent colours of the finer kinds are lead-blue, sometimes red and purple, gray and yellow. The green varieties contain chlorite, and pass into chlorite schist.

Crystalline, or Primary Limestone.

A remarkable peculiarity attending the primary strata consists in the very small proportion which the calcareous rocks bear to the rest of the group, thus affording a striking contrast to the secondary rocks, among which carbonate of lime is so largely developed.

Primary limestone is a simple rock, varying from a highly crystalline texture, both large and fine-grained, to compact. It is of various colours, but generally white. The purest and whitest varieties, sometimes called saccharine limestone, from their resemblance in small masses to sugar, are much prized as statuary marble, and are derived chiefly from the celebrated quarries of Greece and Italy.

This rock is generally met with in irregular beds, alternating indifferently with all the members of the primary series. When in contact with granite it is often indurated, and when very impure, is sometimes converted into a cherty substance. When interstratified with gneiss or mica schist, it is apt to acquire so much mica as not to be easily distinguished from those rocks on a laminar fracture.

The members of the primary strata which occur in the greatest abundance, and in the largest masses, are gneiss and mica slate. The series may therefore be conveniently divided into the gneiss and mica schist systems. The former, which is the lowest, consists of strata of gneiss, mica schist, hornblende schist, quartz rock, primary limestone, and argillaceous schist, alternating in no certain order. In the mica schist system, the most quartzose and felspathic portions are found towards the bottom of the system, the most argillaceous portions towards the upper part. The limestone occurs imbedded in the mica schist.

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* M'Culloch's *Classification of Rocks*, p. 323.

The primary strata occupy a large portion of the surface of the earth. There is scarcely a country in any part of the world in which they are not exposed to view, either by the original absence of the secondary series, or by their denudation or disruption.

They are found in Scotland, Ireland, and part of France; they occupy extensive tracts in Norway, Sweden, and the north of Russia; they constitute the central lines of the Alps, and other mountain-ranges on the continent of Europe, having been brought up from beneath the overlying strata by the subterranean forces which upheaved those chains. They occur extensively in the Brazils, in the United States, and the remotest parts of America which have yet been visited. We know little of the geology of Africa, but they have been found there also. They constitute a large portion of the island of Ceylon; they enter extensively into the composition of the Himalaya Mountains, and are by no means rare in other parts of the continent of Asia. They are indeed so extensively distributed, and wherever found appear under such a general similarity of character, that we are justified in assuming that they exist beneath the secondary strata in all parts of the world, and that they have been produced by some general causes acting during the period of their deposition over the whole globe. The nature of those causes has afforded matter for as much controversy as the origin of the unstratified rocks. Werner maintained that they were formed with the world, and were a chemical deposit from "a chaotic fluid," which held their constituents and those of granite in a state of chemical solution. As the waters of this ocean gradually precipitated the minerals with which they were charged, they became capable of supporting animal life, chemical deposits ceased, crystalline rocks were no longer formed, and the secondary strata were deposited, exhibiting entirely a fragmentary structure, and containing the imbedded exuviæ of animals.

Hutton, a Scotch philosopher, contemporary with Werner, propounded a very different doctrine respecting the origin of the unstratified rocks and the primary strata, which has triumphed over the rival hypothesis, and has been confirmed, in its most important points, by the observations of the geologists who succeeded him. He taught that no geological phenomena afford evidence of the beginning of things; that the oldest rocks we behold are derivative, the ruins of pre-existing rocks destroyed by the slow erosion of atmospheric agency, and that their detritus, borne by rivers to the ocean, and loosely deposited over its bed, became afterwards consolidated by heat, and then upheaved and fractured. The crystalline, or primary strata, according to him, were, originally, mechanical deposits similar to the secondary rocks, but altered by the long-continued action of heat; while granite had crystallized from a state of fusion, and had slowly cooled under great pressure. In support of those views, he and his friends, Playfair and Sir James Hall, collected much of that evidence which we have already adduced as proofs of the igneous origin of the unstratified rocks; and he was himself the first observer of veins ramifying from granite into the superincumbent strata. His delight at witnessing these phenomena exhibited at the junction of the granite with the stratified rocks in Glen Tilt, was so great, that his guides supposed he had discovered a gold mine.

The establishment of the igneous origin of granite has cleared the ground of many difficulties, and that part of the Huttonian theory which relates to the primary strata appears to be rapidly gaining ground among geologists.

The secondary and tertiary strata present unequivocal proofs of a mechanical and aqueous origin. In their arrangement in horizontal beds; in the subdivision of these beds into thin layers, indicating successive deposits, and in the shells which they contain, we have exact counterparts of those beds of sand and silt now forming under our eyes at the mouths of rivers and in ponds and lakes; and some of the tertiary strata are not more consolidated than these modern formations. The primary strata possess the same character of division into thick beds and of subdivision into laminæ; but they contain no organic remains, and they possess a crystalline structure, or, if in any of them we detect obscure traces of a fragmentary origin, those fragments are united by a crystalline cement. The crystalline state of a rock is no proof either of an igneous or an aqueous origin, for crystallization may take place from a state of fluidity produced either by fusion or solution.

We see crystalline beds of limestone that contain organic remains, and are of aqueous origin; we also know that carbonate of lime is daily dissolved, and re-deposited by water, and that siliceous earth is held in solution by the waters of thermal springs. Clay slate, one of the primary strata, never could have resulted from a state of fusion, for it is but clay in different states of induration, and is thus clearly connected with an aqueous deposit. It likewise passes by such insensible gradations into chlorite schist, mica schist, and quartz rock, and these, again, into gneiss, that it becomes sometimes difficult to define the limits between these several rocks; and it is impossible to assign a different origin to substances so closely related. On the other hand, gneiss passes into granite, which we consider proved to be of igneous origin. The Huttonian hypothesis, therefore, which considers the primary strata as an altered condition of sedimentary deposits, appears to offer the only solution to the difficulty.

Whether our planet has ever been in a state of general fusion, and whether it consists, even now, of a mere crust, resting on an incandescent nucleus, as some have supposed, reasoning from the phenomena of volcanoes, and from the increase of temperature in deep mines, we know not; but we are certain that there are masses of melted matter connected with volcanoes, deeply seated below the granite; and large masses of incandescent matter, accompanied by intensely heated gases, *may* have produced in sedimentary strata changes of texture, of every degree between the slightest induration and crystallization. The experiments of Sir James Hall, before alluded to, proved that heat under pressure was capable of forming crystalline rocks out their fragments reduced to powder; and when a specimen of crystalline marble, which he had formed, by this process, out of pounded oyster-shells was shown to a sculptor, he remarked, without knowing its history, that wherever such marble might be found, a quarry of it would be highly valuable. In studying in the laboratory of Nature the phenomena observable when the unstratified rocks have intruded among the sedimentary, we see exhibited, in a more striking manner, and upon a larger scale, the effects of heat upon these deposits. We not only see earthy limestone converted into crystalline marble, but we meet, among the altered rocks, with counterparts of all the primary strata. We see beds of shale converted into jasper and flinty slate, and beds of sandstone into quartz rock, under such circumstances that we can trace the gradual passage from the unaltered into the altered rock. There are also instances in which, when the earlier clay slates have been traversed by dikes or veins of granite, or the basaltic rocks, the slate, near its contact with the veins, is sometimes converted into hornblende schist; in other cases it becomes micaceous, acquiring the character of mica schist or gneiss; and in others, is converted into a hard-zoned rock, strongly impregnated with felspar. In many of these cases, alteration of texture, and re-arrangement of the component particles, appear to have taken place without actual fusion.

The Fossiliferous Strata.

Having now described the unstratified rocks, and the non-fossiliferous strata, and having briefly adverted to the evidence in favour of the igneous origin of the former, and the metamorphic, or changed, condition of the latter, we shall proceed to the classification of the fossiliferous strata. In attempting to divide them into groups, distinguished by mineral composition, we should soon discover that we were engaged in a hopeless undertaking. It is true, we might find some general mineral characters, distinguishing the principal masses over limited regions; but these distinctions would fail us when we should attempt to extend our generalizations to other districts at the distance of only two or three hundred miles. And again, when we should begin to frame a mineralogical classification of the subordinate members of any one of these principal masses, locally distinguished by some peculiar mineral character, such as that of producing coal, or rock-salt, or lead, we should soon be bewildered among the long and varying succession of shales, limestones, and sandstones, with which every fresh section would overwhelm us.

In the organic remains, however, of the secondary strata, we have a clue to guide us out of this labyrinth, and a means of identifying the different formations in very distant localities. The merit of this discovery is due to William Smith, a land-surveyor of Oxfordshire, the "Father of English Geology." He was born at Churchill in that county, a place abounding in fossils, "the playthings of his childhood, and the objects of collection in his early youth. This," continues Professor Sedgwick, "is one of many instances where things, in themselves inconsiderable, act powerfully on peculiar minds, so as to influence the whole tenour of after life. During his boyhood, his habits of observation became confirmed by lessons in practical surveying, he remarked the alternations of argillaceous and stony strata, and thence became acquainted with the origin of springs, and the true principles of draining." During the course of his employment as a land surveyor, he had extensive opportunities of examining the outcrop of the principal secondary strata of central and southern England, and formed collections of their organic remains, which his first care on becoming a housekeeper, in 1795, and having apartments of his own, was to arrange stratigraphically.

He ascertained that certain groups of fossils were peculiar to certain strata, and that by organic remains alone, the true order of succession might be determined, when the beds themselves were obscure. He subsequently extended his observations to the north of England, tracing the strata along their basset edges, and ascertaining their order of succession, and general dip towards the east. He conceived the idea of representing on maps the area occupied by their outcrop, and finally, completed a geological map of England, which was published in 1815. All this he performed alone, unaided, unpatronized, thus accomplishing for England, as was remarked by Daubisson, in twenty years, what many celebrated mineralogists had only effected for Germany in half a century.

The prospectus which he published, in 1801, of a work entitled *Accurate Delineations and Descriptions of the Natural Order of the various Strata that are found in different parts of England and Wales, with Practical Observations thereon*, met with no encouragement. "Why," says Professor Sedwick, "his hopes of patronage were disappointed, and why his works were so long retarded, not by any want of zeal on his part, but by want of assistance from the public, it is not for me now to inquire. The fact, however, is not difficult of explanation. At the time his prospectus made its first appearance, none of the magnificent discoveries of Cuvier and Brogniart, were, I believe, published. The Geological Society had no existence; the branches of natural history connected with secondary geology were little cultivated, and indeed, almost unknown in this country; and hence some persons, perhaps, doubted the reality of Mr. Smith's pretensions, on a subject they had been taught to regard as empirical: and the public at large took little interest in what they did not comprehend. He suffered, therefore, as many men of genius have done before him, in his peace, and in his fortune, from what, in our estimation, constitutes his chief honour,—from outstripping the men of his own time in the progress of discovery*."

The generalization that strata are to be identified by means of the fossils contained in them was soon pushed beyond its proper bounds, and it was supposed that the presence or absence of a particular species or genus, was sufficient to establish an identity between the rocks of the most distant regions. Such distinctions proved as little to be relied on, except within very limited districts, as mineral characters alone; and there is no doctrine enforced more strongly by those whose knowledge of organic remains is the greatest, and who have had the most extensive practical experience in the identification of strata than this, that we can only safely rely on the succession of large groups of fossils.

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* Sedgwick's Address, on presenting Mr. Smith with the Wollaston Medal.—*Proceedings of Geological Society*, p. 277.

ON THE VIBRATION OF CERTAIN VESSELS, CHIEFLY METALLIC.

In a paper recently published in this work, *On the Vibration of Glass Vessels**, we attempted, as far as we could without the aid of mathematics, to give a familiar explanation of the circumstances which enable a glass goblet to emit a musical sound when rubbed or struck, and of the modifications of form and structure which give variety to the tones emitted.

We will now show that a glass goblet is merely one individual link in a chain to which we may give almost any length we please; a sure sign that we have obtained not only a fact, or a collection of facts, but a general *principle*, which binds and blends the whole into one generic system. This is not the place to discuss the subject, but it would be well for students in science to form a just idea of the eminent importance of scientific principles. Principles are to facts what the skill of the architect is to the blocks of stone with which he builds up his structures; each individual stone is not fully appreciated until it is combined with its fellows according to the laws of stability, when each one confirms and strengthens the rest. But to revert to our subject.

If metallic vessels were constructed, resembling glass goblets in form, we should be able to elicit musical sounds from them with more or less facility, in the same manner as from goblets; but there are other forms more easy of construction, and of equal, if not superior, efficacy in practice, without any departure from the principle which governs the glass vessel. To pursue this inquiry, we have had constructed a series of shallow vessels, of various substances, and as nearly equal in thickness as circumstances would admit. The form was that of the common Wedgwood-ware evaporating dishes, being shallow hollow vessels, about five inches in diameter, and one inch and a half deep, with a hole drilled through the bottom to receive a screw, which firmly fixes the vessel for the purpose of experiment. In order to enable such of our readers as may have the wish or the facility for verifying these experiments, to adopt the same mode of conducting them, we will enter somewhat in detail into the kind of apparatus employed.

From a block of wood rises a short wooden cylinder, about two inches high and one inch thick; an internal screw is cut in this cylinder, to which is adapted an external screw with a knob or handle at one end. The vessel which is the subject of experiment is then placed on the top of the short cylinder, the external screw passed through the hole in its centre into the hollow screw cut in the cylinder, and being tightly screwed down, the vessel is in a condition to vibrate freely, as its edge is not interfered with by the screw.

This being the general mode of arrangement, we will state the results obtained from vessels of copper, brass, bell-metal, lead, tinned iron, zinc, and wood: but before we proceed to detail, it is of importance to mention one condition relative to form, which is productive of great modifications in the resulting effect. If the vessel be perfectly circular, any effect produced by applying a violin-bow at one point of the edge, would be the same as if it were applied at any other part; but if the vessel have a lip, as in the case of an evaporating dish, the continuity of the circular form is broken, and we are not justified in concluding that the effects would be similar from every part of the edge.

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* Vol. IV., page 81.

To estimate the amount of difference due to this cause, duplicates of the dishes were made, one with a lip, and the other without; in other respects the dimensions were exactly equal: commencing with the copper dishes, the results presented by vibration were as follows:—

COPPER DISH, NOT LIPPED.—Upon half filling this vessel with coloured water, and vibrating by means of a bow in the usual manner, the lowest tone elicited was found to be B (two octaves lower than the lowest B on the flute), and the accompanying phenomenon observed on the surface of the water was a system of four fans, thereby indicating a division of the vessel into four vibrating segments (as explained in our former paper). On varying the impulse so as to produce the next higher tone, it was found to be E (lowest on flute), and six fans were formed on the watery surface.

In our paper on the vibrations of a glass goblet, we stated that rarely more than four tones can be elicited from the same glass; but the form which these metallic vessels presented, rendered them more susceptible of vibration; and in the copper vessel there were no fewer than five tones, all higher in pitch than E last mentioned: viz. E♭ (second octave), B (ditto), E♭ (third octave), F (third ditto), B♭ (third ditto); and the number of fans observable on the water were respectively 8, 10, 12, 14, and 16. These invariably even numbers afford a strong confirmation of the mode in which the vessel changes its form during vibration, as stated in our last paper; that is, the rapid superposition of two similar figures, which are severally, figures of an elliptical or of a 3, 4, 5, 6, 7, or 8-sided figure. Figures 1 and 3 in our former paper will sufficiently illustrate the nature of these superpositions.

If we compare the musical notes produced by this one vessel, we shall see that they embrace an extensive range of distance; that is, between four and five octaves; and if we likewise bear in mind the fundamental principle laid down, that the acuteness of the tone depends on the velocity of vibration, we at once arrive at the conclusion, that the segments into which the vessel divides itself are vibrating more rapidly in proportion to the acuteness of tone.

Now we will endeavour to convey some idea of the very different degrees of velocity in the vibration producing the several tones elicited from the copper vessel. Supposing that a vibration of only one in a second could produce a musical tone which the ear were capable of appreciating, it has been agreed to call that tone C, and to apply that same letter to indicate every tone obtained by doubling the numbers, beginning from 1. We thus obtain, 1, 2, 4, 8, 16, 32, 64, &c., and all sounds resulting from an intermediate velocity of vibration are called by the other letters which, together with C, form the musical scale of seven letters. If we take the tenth term in the above series of duplications, we arrive at the number 256 for the number of vibrations in a second to which the tenth C is due: this is found to be the middle C of a pianoforte, the slight deviations discernible in different music rooms, and at different cities, being referrible to a slight difference in the standard note by which the orchestral instruments are regulated.

If now we take any one C, and assume any number of vibrations as the exciting cause of that note, it is a constant and invariable rule that the other seven notes of the octave springing from it, are the result of velocities of vibration which bear to the former the respective ratios here given: viz.—

C	D	E	F	G	A	B	C
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2

Taking, therefore, the middle C of the pianoforte (which corresponds with the lowest on the flute) as the result of 256 vibrations in a second, and observing that the lowest tone from our copper vessel is an octave and one note below that C, we arrive at the number of vibrations producing that note by a simple proportion, thus:—as 2 is to $\frac{15}{8}$ (the constant ratio between C and B), so is 128 (half of 256, it being an octave lower,) to the answer required: as $2 : \frac{15}{8} :: 128 : 120$. Thus it appears, that the lowest tone which that vessel is capable of emitting, is the result of a velocity of vibration equal to 120 in a second.

Should a student feel surprised that a copper vessel should change its form 120 times in a second, he must reflect that the power of the mind to conceive rapid motion is bounded by comparatively narrow limits, and he must no more doubt that the fact is so, because he cannot appreciate such a velocity, than that the sun is 800,000 miles in diameter, merely because, to his unassisted eye, it appears so small. One of the results of a healthy tone of mind, is a due appreciation of the power of the senses, whose office of guide to the mind generally, is only exercised with benefit, when under the control of the intellectual faculties in particular, by which its indications are received at all times with respect, and at the same time with caution, never rudely rejecting, nor eagerly accepting. When the mind of ignorance implicitly adopts the senses as guide, the useful servant becomes the treacherous friend, and the master degenerates into the willing slave.

We can now pursue the same system of computations to show the number of vibrations on which the existence of the other tones depends. The lowest C on the flute being due to 256 vibrations, and the second tone from the copper vessel being E, two notes above it, we get another proportion; as $1 : \frac{5}{4} :: 256 : 320$; the first two numbers of this proportion being the ratio between the vibrations producing C and E, as before stated. We thus obtain 320 as the number corresponding to E, and following the same track, we obtain the remaining numbers, which come out thus;—E♭=608, B=960, E♭=1216, F=1365, B♭=1814. We may, perhaps, observe, that for the production of the three flat notes, we have taken a mean between the two notes above and below. If we now remember the number of nodal divisions into which the vessel was thrown, as indicated by the rippling undulations on the surface of the water, we obtain the results represented by the following table:—

Order of Succession.		Pitch of Note.	Octave. (as referred to Flute).	No. of Nodal Divisions.	No. of Vibrations per Second.	Angular Dimensions of each Vibrating Arc.
1st	Fundamental note, or most simple in character.	B	2 Octaves below	4	120	90°
2nd	Secondary tones.	E	1st, or lowest.	6	320	60
3rd		E ♭	2nd	8	608	45
4th		B	2nd	10	960	36
5th		E ♭	3rd	12	1216	30
6th		F	3rd	14	1365	25 43′
7th		B ♭	3rd	16	1814	22 30′

A careful perusal of this table, and a consideration of the manner in which the elements of it have been obtained (with especial regard to the ratio existing between the vibrations producing the seven notes of the musical scale), will give the reader a considerable insight into the fundamental principles of acoustics. The laws which govern that beautiful science may be divided into two classes,—one relating to the production of vibratory action, and the other to the conduction and propagation of those vibrations through the air; the latter we have no need here to refer to, but the former will be brought familiarly under the reader's notice, by referring to the phenomena presented by the copper vessel.

These experiments were followed up by another series, in which the copper vessel, similar in other respects, had a lip protruding at one side. In this case a difference of tone was distinguished, not only as being due to a difference in the number of nodal divisions, but also to the determination of the circumstance whether or not the lip formed part of a vibrating segment: when the bow was applied at the lip, the latter became the centre of a vibrating segment, and there were several other points, which, if chosen as the points of excitation, would place the lip in a vibrating segment; but there were also many points that would place the lip in the condition of a node, or a quiescent part bounded by two vibrating segments. Now, it was found that when the point of excitation was so chosen as to throw the lip into a vibrating segment, the tone was lower, generally by about a semitone, than when it assumed the condition and the property of a node. We must here be understood as implying that the force of excitation was the same in both cases, and the number of liquid fans of undulæ also the same.

It is not difficult to trace the source of this difference; the lip being unsymmetrical in its form, and interfering with the general contour of the vessel, the equability of vibration is broken, and the lip, on account of its spreading form, which gives it the effect of a larger segment, vibrates more slowly, and emits a tone more grave in pitch; but when the lip is placed in the condition of a node its disturbing effect is removed, and the tone elicited from the vessel is nearly the same as if the latter were perfectly circular. It will likewise be easily conceived that the more the lip is thrown out of the general circle of the vessel, the greater will be the discrepancy. Under any such circumstances as these, the vibrating power of the vessel is lessened, and the number of tones capable of being elicited from it will be small.

In order to compare the phenomena presented by this vessel with those detailed respecting the vessel without a lip, we will subjoin a similar table, in which the effects of the lip are estimated by the difference of tone and difference of velocity in the vibrations producing them. The reader will understand that when the lower tone of any given nodal division is mentioned, it is implied that the bow is applied at the lip, but that when the higher tone is alluded to, the bow is so applied as to throw the lip into the condition of a node.

Order of Succession.		Pitch of Note.	Octave, (as referred to Flute).	No. of Nodal Divisions.	Angular Dimensions of each Vibrating Arc.	No. of Vibrations per Second.
1st Fundamental tone.		B B♭	2 Octaves below	4	The form of the lip rendered this indefinite.	120 114
2nd	Secondary tones.	E E♭	1st	6		320 307
3rd		E♭ D	2nd	8		608 576
4th		B B♭	ditto	10		960 907
5th		F E♭	3rd	12		1365 1216
6th		B♭ A♭	ditto	14		1814 1622

Here, then, we see the nature of the influence which any interruption to the continuity of the circular form exerts. We shall have to make a few remarks on other similar obstructions, but we wish at present to pursue the details respecting the metallic vessels.

The two hitherto described were of copper; but the next experimented on were of brass: in these the facility of vibration was not equal to that in the copper, considered with reference to the number of tones produced, there being only five in the brass vessel without a lip, and only three doubled tones in the lipped vessel. By doubled tones we mean the two depending on the same number of nodal division; but the range embraced by those five tones was remarkably extensive, the lowest being an octave lower than the lowest E on the flute, and the highest being the 5th A above it,—an interval of nearly 5½ octaves, the lowest being due to 160, and the highest to 3413 vibrations in a second of time. No musical instrument (used as such) can give any idea of the piercing acuteness of this upper tone: it is elicited (as, indeed, are all the tones emitted by these vessels) by a peculiar handling of the bow, which gives a sudden but not a violent impulse to that portion of the rim of the vessel on which the bow is placed. The lipped brass vessel presented a similar feature to that of the copper vessel: viz. a deepening of the tone when the bow was applied at the lip; the extent of this depression of pitch was about a semitone, but not musically accurate in that interval.

Two dishes formed of bell metal were then made the subject of experiment: in that which had not a lip, the highest tone was the same as in the brass vessel, but the lowest was not so low in tone by an octave as the lowest in the brass vessel, the interval between the different tones not being so wide; the notes produced were F, B ♭, A, F, A, the former four of which were all in different octaves. An eye accustomed to musical symbols will instantly see that there is no harmonious relation between the different notes if sounded together; and the same remark applies in the former instances with even still greater force.

The employment of tinned-iron vessels was productive of very favourable results, as they admitted of being made very thin, without injuring the elastic character of the metal. From the tinned-iron vessel without a lip seven tones were elicited, which, if they could have been heard at one time, would have been even more discordant than those before alluded to: they embraced a range of about 4½ octaves, the lowest, B (one octave lower than flute), and the highest F ♯ (octave higher than do.) the former being due to 120, and the latter to 2902 vibrations in a second.

The lipped vessel of the same material presented results very similar to those previously described, there being, however, five doubled tones, whereas the brass emitted but four. It might not, perhaps, be expected that zinc would be particularly calculated for these experiments; it will be seen, however, that it is not behind the more sonorous metals (as they are generally considered) when vibrated in the manner which we have adopted. The whole series of tones were higher in pitch than in any of the former vessels; the lowest, or fundamental tone being the lowest E on the flute, while the highest was A, *two octaves* above the compass of the same instrument; the tones produced were seven in number, discordant as before, when considered harmonically, and accompanied by a breaking up of the liquid surface into 4, 6, 8, 10, 12, 14, and 16 vibrating segments respectively.

Lead, from the difficulty of forming it into vessels of great thinness, and from its generally inelastic character, is a very unfit source of sonorous vibration; two vessels, however, formed of that metal, yielded two tones each, one due to quadrinodal, and the other to sex-nodal division: the interval between the tones was 1½ octaves, the notes being G and C in adjacent octaves. A vessel formed of the same material, and provided with a lip, yielded the same two tones when the lip was chosen as the point of excitation, but each was lowered a semitone when the lip was made to assume the position of a node.

The next pair of vessels were of wood, being formed of hard beech, turned to a considerable degree of thinness. From these vessels, that without a lip yielded three tones, viz. B ♭ (below first octave of flute), F (1st octave), F (2nd do.), the result respectively of 240, 341, and 682 vibrations in a second. The lipped beech vessel emitted E and C ♯ (octave below flute) with 4 vibrating segments: G ♯ and G (1st octave) with 6 segments: and G and F ♯ (2nd octave) with 8 segments.

With respect to these vessels of wood, the wonder is, not that the notes were limited to three in number, but that so many as three could be produced, considering the material of which they were made. The unlipped vessel furnished an interesting example of the effect produced by a want of homogeneity in the structure or texture of a vibrating body. The vessel had been slightly cracked, but the fissure firmly glued up again: the effect of the glue, however, gave a rigidity to that part of the vessel, and when the part happened to be a centre of vibration (or midway between two nodes) the resulting note was a quarter of a tone *deeper* than when the same part was in the condition of a node. The explanation is at once easy and instructive: when the defective part was at a nodal line, its rigidity was of no moment, as it took no part in the vibration; but when it became a centre of vibration, it slackened the velocity by its greater stiffness and imperfect elasticity. It was curious also to observe, in many of these instances, that any inequality in the thickness of the material of which the vessel was formed always produced a slight depression of the tone, when the thickened part became a centre of vibration; the same remark which applied to the glued fissure in the wooden vessel will avail to explain the cause of this depression of tone.

The vessels which we have now described were all made to the same dimensions, in order to bring them more prominently into comparison with each other. Subsequently, however, a similar train of experiments was instituted on the vibration of a larger vessel, nine inches in diameter, and made of zinc, and the result will show how greatly the power of producing these tones is increased by employing larger vessels: it is obvious, from a comparison of the results obtained from this vessel with those elicited from the smaller vessels before described, that we can place no limit to the extent to which these tones can be produced by increasing the size of the vessel, with the understood proviso that the circularity of form, homogeneity of structure, and equability of thickness, are attended to as much as possible.

We will give a tabular view of the results obtained from this vessel, as the nature and extent of the increased facility resulting from the employment of a large vessel will be better appreciated by instituting a comparison between those results, and the particulars enumerated in the two preceding tables.

Order of Succession.	Pitch of Note.	Octave, (as referred to Flute).	No. of Nodal Divisions.	Angular Dimensions of each Vibrating Arc.	No. of Vibrations per Second.
1st Fundamental notes.	F E	Octave below the range of Flute.	4	90°	171 160
2nd Secondary tones.	B A♯	ditto	6	60	240 226
3rd	A	1st octave	8	45	427
4th	C♯	2nd ditto	10	36	544
5th	E D♯	ditto	12	30	640 608
6th	A G♯	ditto	14	25 43′	853 810
7th	C♯	3rd ditto	16	22 30′	1088
8th	G F	ditto	18	20	1536 1365
9th	B♭	highest	20	18	1814

It must be observed that this vessel was provided with a lip, and the doubled tones given above were determined by the nodal or segmental *position of the lip.* A few vacancies will be seen in the filling up *of the table; this* arose from the great difficulty of eliciting any given tone with sufficient continuance to estimate both the pitch of the tone and the number of liquid fans on the surface of the water, and those only having been included in the table whose value was duly appreciable.

From the experiments now described, we obtain an idea of the modifications which a lip produces on the tones elicited from a vessel of a form in other respects circular; but we may trace the existence of a similar principle when the circle is broken by any obstacle which retards the vibration at any given point.

If we take a common drinking mug or cup with a handle, and vibrate it by means of a bow (observing at the same time that no part of the sides of the vessel is touched by the hand) we shall find that when the bow is applied at such a point as to place the handle in the centre of a vibrating segment, the tone heard at that moment is a semitone lower in pitch than when the handle assumes the character of a node: this may even be detected by resting the vessel on the hand, and passing the finger round the edge. If we listen for a sound analogous to that emitted from a glass goblet under such circumstances, we shall certainly fail, but by applying the ear close to the vessel, we shall detect an exceedingly faint and soft sound, which we may, perhaps, without incorrectness, call a musical whisper; and it will likewise be found that when the finger is passing close to the handle, or at a point diametrically opposite to, or at 90° from that point, the sound will be considerably lower than at the four intermediate positions. That the existence of the handle is the cause of this depression of tone is sufficiently shown by cutting off the handle (which may be done by means of a small saw moistened with turpentine), and when the amputation is neatly and cleanly performed, the vibrating power of the vessel is not at all injured, and the tones elicited from it are the same in pitch, whatever part of the edge be chosen as the point of excitation.

There are some earthenware and glass vessels, in which the outer surface is fluted, or reeded, or both; and whenever such a state of things occurs, the depth of the tone is sure to be influenced by the determination of the circumstance whether or not the reeded or thickened part be in active vibration.

If any circular body be taken, such as a common plate or a disk of glass or metal, if the disk be mounted, and held firmly in the centre, a certain number of tones is producible from the same disk, at whatever part of its edge the bow be applied, but this number of tones can always be exactly doubled, by screwing to the edge a damper, as mentioned in the former paper; the damper acts the part of the lip and handle in the vessels whose vibrating action we have just considered. If disks be employed, and it be desired to employ a liquid upon them, this is easily effected by melting some bees-wax, and running it round, a little within the circumference; in this way a disk is converted into a very shallow vessel.

In all the experiments which we have detailed, in which metallic vessels were made the subject of inquiry, they were filled to about half their height with water; this necessarily deepened the tones elicited from them, for at every vibration, each segment of the circle has to move, not *only itself*, but a bulk of water resting against it; thus the velocity of vibration is diminished, and the tone resulting, therefore lowered in pitch. It is, therefore, probable that if no water were present in these vessels, a greater number of tones might be elicited than those which we have mentioned, but the desire to ascertain clearly the number of segments into which the circle was divided in each instance, led to the employment of water, as it indicated the nature of the impulse to which the glass was subjected with undeviating accuracy.

It may here be observed, that the fans on the surface of the water, extend a smaller distance towards the centre of the liquid surface, in proportion to their number: this obviously follows from the circumstance that as the number of vibrating segments increases, the dimensions of each and the extent of its vibratory excursions diminish, and the water which presses against it, receives a smaller impulse.

We have now stated the principal results obtained from this series of experiments; and have endeavoured throughout to trace the production of the observed phenomena, to causes which are, in most cases, adequate to their explanation,—so far as that can be done, without the aid of mathematics; before quitting the subject, however, we wish to subjoin a few details on the effect of the application of heat to sonorous bodies.

All the vessels which were used in these experiments, were at the ordinary temperature of the atmosphere: several of them were, however, afterwards raised to 200° or 300°, in order to ascertain whether any change of *tone* resulted from the change of temperature; but it did not appear that such was the case, the only change being that the tones assumed a *cracked*, imperfect character, by no means equal to that elicited at ordinary temperatures.

How far heat, as a general principle, influences musical tones, is not yet well understood; but there is an experiment not popularly known, which places in a prominent point of view, the agency of heat in producing sound.

Mr. Trevellian, a few years since, accidentally discovered, that when heated metal is placed upon cold metal, in such a manner that a *rocking* can easily be produced, the rapid passage of caloric from the heated to the cold metal, will engender a tremulous motion of the former, and with such great rapidity that a very perfect and beautiful musical note is produced. One method of performing this experiment is as follows: an oblong plate of copper, about half an inch thick, and convex on one side, and having a rod or handle projecting from the centre of one of the short edges, is heated to between 300° and 400°, and then placed across a ring of cold lead, about six inches in diameter: the heat immediately darts from the heated copper to the cold lead, and with such a degree of momentum, that the copper plate, being convex on its under surface, and resting on a notch cut in the ring of lead, rapidly rocks to and fro, as a watch-glass would do, if laid on a table, with its convex side downwards, and touched with the finger.

Wishing to ascertain how far the analogy of the metal vessel would apply to this heated copper-plate, we have performed the experiment with that view, and found that when the plate was vibrating, besides the principal tone produced, which bore some resemblance to the tone of an organ, and was very rich and perfect in its character, there was always another tone to be heard, of a higher pitch; this upper tone, however, was not always harmonically related to the fundamental note; for instance, in one experiment the tone elicited, was G (lowest on flute), and a faint B a tenth above it was also heard at the same time; in a few minutes, when the temperatures of the two metals had become less dissimilar, the fundamental tone suddenly changed to E flat; while the secondary tone became likewise E flat. In another experiment, the interval between the two tones was a fifth which suddenly changed to a seventh, when the heat had partially equalised itself: thus showing that although a secondary tone could always be distinguished, it bore no constant relation ro the fundamental tone: it should be observed that the metals are placed on the cover of a very thin wooden box, which acts as a sounding-board, and by its resonance, greatly invigorates the tone.

It thus appears from the results which have been detailed, that in the goblet, in the metallic and wooden vessels, and in the copper-plate, the secondary tones bear every sort of musical relation to the proper or fundamental tone, and that however gratifying to the mind it may be, to generalize facts, and seek for analogies between different phenomena, we must be carefully on our guard to avoid *forcing* a coincidence or resemblance between different classes of phenomena; such, for instance, as those which we have been considering, and those connected with the vibration of a stretched cord; in the latter case, during the production of any given tone by the application of a violin bow, two or three harmonic tones can be heard, such, in fact, as we have called *secondary tones*, but with this especial difference, that in the string, the secondary tones are the 5th, the octave, and the 12th, above the fundamental tone, and are, therefore, in perfect harmony with it, hence the term *harmonic;* but in the instances of these circular vessels, the relation between the different tones, presents every sort of interval, concordant and discordant. This must caution us against straining an analogy further than it will apply. Physical facts are to principles what scions and buds in the process of grafting and budding are to stocks—if the scion or bud of one species be grafted upon the stock of another species, between which Nature owns a relationship, however distant, the result will be most beneficial; but if we endeavour to assimilate different families, to force an affinity which Nature refuses to sanction, the result will show that we have made a bad use of good materials.

ON TIME-KEEPERS. I.

INTRODUCTION.

FROM the earliest ages mankind must have felt the want of some method of *measuring time;* that is, some method of ascertaining when equal portions of time have elapsed, and whether the time between any two particular occurrences is equal to, greater, or less, than that which has passed between any other two. If we attentively reflect on what the word *time* means, we shall perceive that it is only by the *succession* of our perceptions, or of our thoughts, that we are made conscious of its passage; and that it can only be by means of some species of MOTION of external objects that we can make this passage of time apparent to our senses.

From our perfect conviction[*] that *the same means*, if applied under *exactly the same circumstances*, will always produce *exactly the same results*, we feel certain that, if the same *body* is moved by exactly the same *force* at different times, that body will move through exactly the same *space*, in what we thence conclude to be exactly equal portions of *time*. Consequently, if we can contrive an instrument, by means of which the *same body* is moved by a *constant force* repeatedly through the *same space*, each portion of time occupied by that motion will be equal, and we can, by the aid of such an instrument, compare the intervals of time between any other events, by observing whether this body has moved once, twice, or any number of times, through that same space. Long, however, before man becomes sufficiently civilized to invent such an instrument, the constant and equable motions of the sun, and the other heavenly bodies, would suggest the idea of employing them to effect the desired purpose.

It would be soon observed that, though the arch in the heavens through which the sun moved in the day time was much longer in summer than in winter, and that, consequently, a longer portion of time elapsed between the sun's rising and setting in the former than in the latter season; yet that, at all seasons, that luminary moved with a regular and equal motion, and that the time between its being at the greatest height above the horizon, and its returning to the corresponding greatest altitude the following day, was equal all the year round. And the same remark would be made with regard to any, or all, of the fixed stars during the night; the period between the successive return of any of the same stars to the meridian being always exactly equal. And since the change in the length of the daylight, however considerable, is gradual, the time of the sun's rising or setting from day to day would afford an intermediate point for guiding and influencing the few occupations of uncivilized life. As soon as the necessity was felt for subdividing the period between the rising and setting of the sun into smaller portions of time, the shadow of a tree, as it moved over the ground slowly in the contrary direction to the motion of the luminary, would most probably be observed and employed for that purpose. For, though the shadow of a tree, or other upright object, would not move over equal spaces on the ground in equal portions of time, or corresponding to equal portions of the motion of the sun or moon, yet such a shadow would present a rude mode of estimating portions of time sufficiently correct for common purposes. The observation of the motion of such a shadow suggested the idea of a SUN-DIAL, and sufficient knowledge of astronomy and mathematics were attained at a very early period in the history of man, to admit of dials being constructed with considerable accuracy.

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[*] That is, from our conviction of the constancy of the physical laws of nature.

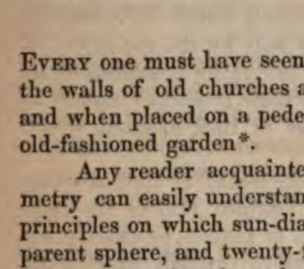
THE SUN-DIAL.

EVERY one must have seen a sun-dial, since they are to be found against the walls of old churches and buildings in every part of the kingdom; and when placed on a pedestal, they constitute an ornament of many an old-fashioned garden*.

Any reader acquainted with the elements of astronomy and geometry can easily understand the following general explanation of the principles on which sun-dials are constructed. If the earth were a transparent sphere, and twenty-four circles were drawn on its surface, at equal distances, passing through the poles; then, as the earth turned round on its axis in its daily motion, each circle would be brought in succession under the sun, or the sun would be in the *plane* of each circle; and since the axis of the earth is in the plane of *all* these circles, if that axis were an opaque line like a wire, its shadow would be cast on the concave half of each circle in succession, at the end of every hour, or the twenty-fourh part of the time the earth took to make a complete revolution.

Now, since the distance of the sun may be considered as indefinitely great when compared to the size of the earth, any small transparent globe, divided into twenty-four equal parts by hour-circles passing through the poles, and having the axis on which it turns parallel to the axis of the earth, would, if it turned round regularly in twenty-four hours, present the same appearances as the real earth, and the shadow of the wire axis would fall on the hour circles in succession as above explained.

Fig. 1.



If this artificial globe were cut by a plane A B, passing through its centre parallel to the horizon of the place where the globe was, this plane would be cut by those of the twenty-four circles in straight lines, radiating from the centre of the sphere; and the shadow of the half axis above the horizontal plane would fall on these lines in succession every hour, as it would have done on the circles on the sphere if the plane were not there.

These straight lines can be drawn by simple geometrical rules, on a flat surface, supposed to represent the cutting plane A B; and if a piece of brass, or other substance, called a *gnomon*, with a sharp edge called *the style*, be fixed on the surface, so that this style shall be truly parallel to the axis of the globe, or earth, the shadow of this edge would move from one line to another in an hour, and thus divide the day; this constitutes a *horizontal sun-dial.*

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* *There is*, or was, one in Kensington Gardens, in Clement's Inn, Temple, &c. &c.

If, instead of lying horizontally, a dial be required to be fixed against an upright wall, the lines on it must be drawn as they would be produced by the circles of the imaginary globe, when cut by a plane *perpendicular* to the horizon, instead of parallel to it as before; the planes of these circles would cut this upright plane in straight lines radiating from the centre of the sphere, or of the circle; but in this case it would be the lower half of the axis which would become the style of the dial, as may be understood from the opposite figure.

Dials are so ancient that there is no positive knowledge of the date of their invention; that they were employed by the Jews 750 years B. C. is proved by Scripture. "Behold, I will bring again the shadow of the degrees, which is gone down in the sun-dial of Ahaz ten degrees backward. So the sun returned ten degrees, by which degrees it was gone down." (Isaiah xxxviii. 8.) Dials were not introduced at Rome till about 300 years B. C.

But it was in time discovered that the sun-dial, though infallibly accurate, and never out of order, was objectionable on several accounts; it was only available during the day time, and was useless in cloudy weather, and being, from its principle, a fixture, it could not be moved about where wanted, nor brought into a house or any covered place. Hence new measures of time became requisite to supply its deficiencies.

CLEPSYDRÆ, OR WATER-CLOCKS.

THE second instrument of any importance, invented to measure time, was the CLEPSYDRA, so named from Greek words, meaning *to divide water.*

If a vessel, having a small hole in its bottom, be filled with water, this may be caused to run out by various contrivances at nearly the same rate [*], or so that equal quantities of water may escape in equal portions of time. If the vessel were made to hold just such a quantity as would thus empty itself in six, twelve, or twenty-four hours, it would only be necessary to refill it after the lapse of each period, and then divisions on the inside being marked at proper distances, any one, by looking at the vessel, could tell what time had passed since the water had been poured in, by observing at what mark it then stood.

This instrument would, however, require many additions and improvements to make it effective; the object of these being to equalize the rate at which the water flows off, to obviate the necessity of frequently refilling the vessel, to render the division of time by means of it more easily recognised than by inspecting the inside, and to adapt the instrument to the variation in the lengths of the hours, which was the result of the mode of dividing the day employed among the nations where the clepsydra was invented and used. The Egyptians divided the time between the rising and the setting, and between the setting and rising, of the sun into twelve hours; consequently, their length varied for every day and night in the half year.

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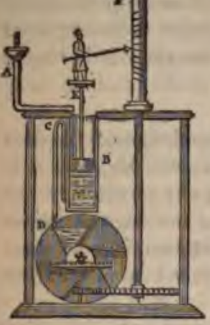
[*] If the vessel were of a cylindrical form, the water would run out much faster when the vessel was full, and the rate would diminish gradually in proportion as the vessel became empty, owing to the greater pressure or weight of the water over the hole in the former than in the latter state.

The annexed figure represents one species of clepsydra, said to have been contrived by Ctesibius of Alexandria, about 145 years B.C., and will sufficiently explain the mechanism of this instrument.

Fig. 2.



The water flowed constantly and regularly, out of a vessel not shown in the figure, through the narrow pipe A, into the cistern B, and gradually filled it in one day of twenty-four unequal hours; and when the water, which rose in the leg of the bent tube, or *siphon*, communicating with B, flowed over the bend at C, this tube, which was of a sufficient size, rapidly emptied the vessel into one compartment, D, of a kind of water-wheel, and caused this to turn round, so as to empty out the water again, owing to the weight of this water, when in the cavity D, acting on one side of the axle of the wheel. The wheel which was thus turned round a portion of a revolution in each day, had pinions and toothed wheels connected with it, which caused the column F to turn round on its axis once in a year, or $\frac{1}{365}$th part of a whole turn each day. This column had curved lines drawn on and round it, so contrived as to divide every straight line running up it into twenty-four parts, varying in their distances according to the change in the lengths of the hours, arising from the mode in which the day was divided; thus a new scale was each day brought opposite to the figure placed on the top of a rod, E, carried by a float in the cistern B; the figure having a dart in its hand, with which it pointed to the divisions on the column.

When the cistern was empty, and the float with the figure had descended to the bottom, the dart pointed to the lowest division of the scale, and, as the cistern gradually filled, the figure rose higher, and pointed to each succeeding division after the lapse of each hour; when the cistern was filled up level with C, the dart pointed to the last hour of the day; the cistern then emptied itself, the wheel D turned round, and caused the column to turn $\frac{1}{365}$th part; the figure sank to the bottom of the scale, and began to point to the divisions of a new day.

Clepsydræ have been contrived by ingenious mechanists in the middle ages, which showed the phases of the moon, the minutes, and seconds, and all the other movements of clocks, including striking the hours and playing chimes; but this will excite no surprise, if it be remembered that, when once a *continued moving power* is obtained, there is hardly any limit to the complication of movements which may be effected by a sufficient combination of wheels and levers. Now the flowing of water in a clepsydra corresponds to the *weight* of modern clocks, or to the *spring* of a watch. The clepsydra was still more objectionable than the sun-dial, though, from other causes; it was incapable of any tolerable accuracy of action, owing to the evaporation of the water constantly varying with the season, or even during one day, and therefore affecting the *going* of the machine; added to which, its unwieldiness and the frequent adjustments it required, all contributed to cause its being abandoned as soon as increasing knowledge enabled man to contrive better instruments for the purpose of measuring time. To this day, however, we make use of a species of clepsydra, though it cannot be properly so called, since *sand* is employed instead of water; an *hour-glass* is the simplest possible form of this contrivance, which, from its simplicity and utility, though this is very limited, still maintains its station in many cottages, and is also used on a few other occasions.

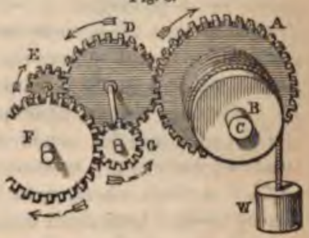
It is supposed that the clepsydra is nearly as ancient an invention as the dial; it was introduced into Greece in the time of Plato, and had been before employed by the Chinese, the Indians, and Chaldæans. Julius Cæsar found it in Britain on his landing there; but whether it had been introduced by the Phœnicians in their commercial intercourse with our island, or whether the natives had invented it themselves, we have now no means of ascertaining.

There are columns existing in the ruins of several ancient cities, which, by their form and construction, evidently appear to have been erected for the purpose of serving as clepsydræ. In Athens, near the Acropolis, there are traces of such a work, and still more distinctly in the neighbourhood of the singular and celebrated city of Balbec.

Of the Clock and its Mechanism.

In all machinery, when motion is intended to be *continuous*, it is communicated by means of circular wheels, acting on one another, because the edge or *circumference* of a circle is an *endless line*, as long as the wheel continues turning round and round on its *axle*.

Fig. 3.



Let A be a wheel fixed at the end of a cylinder B, round which a cord is wound having a weight W hanging to it, the axle C passing through the centres of the wheel and cylinder, being supported at each end (the supports are not shown); then it is clear that the weight, in descending by the force of gravity, will cause the cylinder and wheel to turn round and round, till the whole cord is unwound off the former.

If the edge of the wheel A be cut into *teeth*, or *cogs*, as shown in the figure, it can, by means of equal teeth in the edge of a similar wheel, D, cause this last to turn round, though in the opposite direction: for each tooth of the first wheel, A, fitting into the space between two teeth of the second, D, will press against one of these, and will force D to turn if A be set in motion. The first wheel, A, will, by the action of the weight, turn round from *left* to *right*, in the direction shown by the arrow; and as each tooth on the *left* side rises upwards, it will force that on the *right* side of D, against which it presses, to rise upwards also; but by so doing, D will turn from *right* to *left*, as is shown by the arrow near its edge; that is, in the contrary direction to which A turned.

If the two wheels were of equal diameters, there would be the same number of teeth in the circumference of each, and it is obvious, therefore, that the first wheel, A, while it turned once round, would cause D to turn also once round in the same time. If the second wheel were *smaller* than the first, it would turn round oftener than once, while the first made only one revolution; and if the second wheel were *larger* than the first, then, while this last made one revolution, the former would not turn completely once round, or would only make part of a revolution.

For the teeth of both wheels, and the spaces between them, being necessarily equal, to allow of their fitting into one another, it is clear that, while any tooth of the first wheel is moving through a certain portion of the circumference of the circle described by it in its motion, that tooth will force the corresponding one in the second wheel, against which it presses, to move through an *equal length* of the circumference of the circle described by that second tooth; but if this circle be *less* or greater than that described by the first tooth, this equal length of its circumference will bear a *greater* or less proportion to the whole, or to a complete revolution; or the *angular velocity* of the second tooth will be greater or less than that of the first.

To illustrate this, let the first wheel, A, have thirty-six teeth, and the second, D, be exactly half the diameter of A, and, consequently, have half the number of teeth that A has, or eighteen teeth in its circumference. Now, since these teeth and the intermediate spaces are equal in both wheels, while a tooth of A is moving through the whole circumference, or through thirty-six, a tooth of D, to move through thirty-six, must move through twice the circumference of that wheel; that is, D must turn round *twice* while A turns *once* round. Again, if D were *twice* the diameter of A, and therefore had its circumference twice the length of that of A, there would be seventy-two teeth in D; and A must turn *twice* round to make D turn *once*, or D would only make *half* a revolution while A made a *whole* one.

By this simple principle, the *velocity* communicated by a *moving force*, such as the weight W, to a wheel A, may be *increased* or *diminished* by causing A to turn a second wheel smaller or larger than itself. And if a third wheel, E, to be turned by D, were added, the wheel E differing in size both from D and A, its velocity would vary from that of the two former wheels.

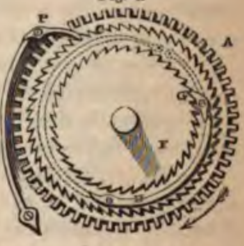
Let the first wheel, A, have thirty-six teeth, D, the second, thirty-two teeth, and E, the third, sixteen: then, while the weight causes A to turn round *eight* times, D will be turned *nine* times in the contrary direction, and will cause E to turn *eighteen* times round in the same direction as A, as will be seen from the arrows.

But greater difference in velocity may be obtained in a simpler form, and in less space, by placing wheels of different diameters on the same axle. Thus, if the axle of the wheel D had a smaller wheel, G, fixed on it, which again turned a wheel, F, on the axle of which, but not fixed to it, a fifth wheel, E, were set, E receiving its motion directly from D: then, while G and C make one revolution, both being fixed on their *common* axle, it is clear that the small wheel E, which is turned by D, will move very fast in comparison with the larger wheel F, which receives its motion from G.

For example, suppose D had ninety-six teeth, E eight, and G and F to be equal, and therefore to have any, the same, number of teeth; then by the combined motion of D and G, E would be turned round twelve times, while F was turned round only once; consequently, if a *hand*, or index, were fixed on the axle of E, and another on that of F, passing through the axle of E, then the former might be the *minute*-hand, and latter the *hour*-hand of a clock.

We thus see how motion of any degree of velocity may be imparted to a variety of wheels, acting on one another by means of a body descending by its weight, or by the force of gravity. But it will be easily perceived that in the present arrangement of the wheels and weight, this last will descend very fast, and will cause the wheels to turn round faster and faster, till all the cord is unwound off the cylinder, or *barrel*, as it is termed, and then all motion will cease. In order, therefore, to renew the action, it would be necessary to re-wind the cord round the barrel, and so raise the weight again. If this were done by turning the barrel round and round in the contrary direction to that in which the weight, while descending, caused it to turn, the wheels, by so doing, would be turned backwards, and would undo all that had been gained by the first descent of the weight: and further, this process would have to be repeated perpetually. The first of these difficulties is obviated by a very simple and beautiful contrivance, which will be now explained.

Fig. 4.



The *barrel* has a wheel F, fixed at one end of it, which is cut into sloping teeth like those of a saw; such a wheel is technically called a *ratchet*-wheel; the common toothed wheel, A, turns freely on, or is not fixed to, the common axle; on this wheel A, a small metal piece G, with an edge, called a *click*, is screwed; the edge of this click is pressed against the teeth of the ratchet-wheel by a slender spring H, which is also screwed to A. Now, from the form of the teeth of the ratchet, when the barrel moves from left to right by the descending weight, the tooth which presses against the click forces the wheel A to turn round with the barrel in the same direction, or produces the same effect as if A and the barrel were *fixed* together on the common axle; but when the barrel is turned round in the *contrary* direction, from right to left, in order to wind the cord on it again to raise the weight, the sloping backs of the teeth of the ratchet allow the click to slip over them, and the wheel A is not moved, but keeps its position. When all the cord is wound on the barrel again, then the spring, which always presses the edge of the click into the notches of the teeth, causes the click to press against the last tooth which passed it, and again carries A on in the same direction as before with the barrel, which is now set in motion again by the weight.

The *winding up* of the weight is accomplished by the end of the axle, which projects beyond the support, being made square instead of round; a *key*, or handle, with a square hole in it, into which the squared end of the axle fits, being then applied to the axle, the barrel can be turned round by hand.

This mode of *winding up* by a key on the squared end of an axle, is applied in all machines where the moving power requires to be renewed, as in the common bottle-jack for roasting meat, &c.; and in all such machines there is a *ratchet-wheel and click*, for the purpose of preventing the act of winding up, or of renewing the moving power, from turning the wheel-work back again, and so undoing what that power had previously accomplished.

But the free descent of the weight before alluded to is productive of another fatal defect, besides the necessity of frequent winding up. From the well-known law relating to the falling of bodies by the force of gravity, the weight moves quicker and quicker as it descends lower, and therefore causes the wheel-work also to turn with an accelerating velocity; if, therefore, the wheel-work moved a hand or index, this, instead of moving round through *equal arcs of a circle in equal portions of time*, would move faster and faster as the weight descended, and could not, therefore, serve as a measure of equal portions of time, as required. Some regulator and check of the descent of the weight is therefore necessary.

If a heavy body be hung by a string, or wire, from a fixed centre, so as to swing freely, if drawn out of the perpendicular line in which it hangs when at rest, and then let go again, it may be demonstrated mathematically, that each *vibration*, or *oscillation*, as it is called, of such weight, that is, the motion from one end to the other of the arc through which the weight moves, is performed in the same time whether that vibration be long or short. A weight so suspended and swinging backwards and forwards is called a *pendulum**.

When a pendulum is made to oscillate, and then left to itself, it continues swinging for some time; but the length of the arc described by it gradually diminishes till the pendulum stands still: two causes co-operate to produce this effect.

The air, like any other fluid, presents a resistance to a body moving through it, and in the case of the pendulum, this resistance of the air gradually weakens the force with which the weight moves, and at length destroys it altogether, when the motion must cease; but the force of the moving weight is also being constantly diminished by the *friction* or *rubbing* of the parts where the pendulum is suspended. If we could suppose these two sources of impediment entirely removed, it may be demonstrated that a pendulum, when once set oscillating, would continue moving for ever, always describing an equal arc in precisely the same time, while the weight remained the same, and the rod of the same length. But since it is impossible to effect this in practice, in order to cause the weight to describe an equal arc, it is necessary to renew the power which sets the pendulum swinging, so as to overcome the effect of resistance of the air and friction, and this being accomplished, then, as long as the length of the rod, or string, by which the weight hangs, remains unchanged, and the arc continues of the same length, the time of each oscillation will be the same.

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* It should be mentioned, that when a pendulum describes the arc of a circle, which it must do if suspended by an inflexible rod from a fixed point, it is only true within certain limits that the *times* of the vibration are very nearly equal; that is, only when the arc does not exceed four or five degrees. But there is a curve called a *cycloid*, which a pendulum can be easily made to describe in oscillating; and then the oscillations are exactly equal in time whether the arc be long or short. Practically, however, the pendulum always moves in a circular arc, even in the best clocks, and this arc not exceeding two degrees, and being, from the construction of the clock hereafter described, always of the same length, the theoretical error is not appreciable.

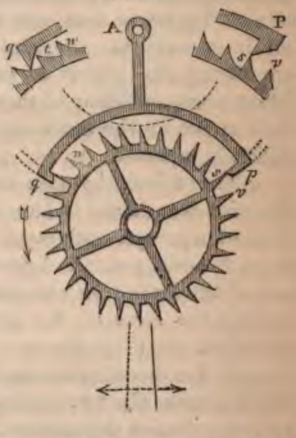
We shall now proceed to show how the wheel-work of a clock is made to renew the force of the weight of a pendulum, so as to keep it swinging in an arc of equal length; and how, in return, the pendulum regulates and retards the descent of the weight W, so as to equalize its velocity, and to increase the time of its action; and therefore cause a hand or index moved by that wheel-work, to describe equal arcs of a circle in equal portions of time, for a considerable period, and thus to constitute an effectual and accurate measurer of time.

We have seen that the weight by descending keeps turning the wheels round in one *continued* direction, while the motion of a pendulum is backwards and forwards, or *alternating;* a contrivance is therefore previously necessary to combine these two different species of motion, so that they may act together.

A wheel, with teeth of a particular form, as shown in the adjoining figure, is fixed on the arbor of a *pinion*, or small toothed wheel, and receives a *circular*, *continued* motion directly from the main wheel on the end of the barrel, or by intermediate wheels if necessary, as will be hereafter explained.

Above this *swing wheel*, as the one in question is called, an *arc*, having a hook, or tooth, of a peculiar form, called a *pallet*, is fixed on a horizontal axle, at A, so that if the arc be swung backwards and forwards, the pallets would pass alternately between the teeth of the wheel below them; but before explaining minutely the mode in which these pallets are acted on by the wheel, it will be necessary to show how the oscillations of the pendulum are communicated to the arc. Fixed to the further end of the horizontal arbor A carrying the arc there hangs a wire, the lower end of which is bent up and formed into a fork, and the rod of the pendulum hangs between the prongs, the fixed point from which the pendulum is suspended being quite independent of all the wheel-work of the clock. As the pendulum vibrates, it communicates its oscillations to the arc and pallets by pressing alternately against the prongs of the fork; and, conversely, any motion given to the pallets, is communicated through the fork to the pendulum.

Fig. 5.



When the pendulum is arrived nearly at one end of an oscillation to the right, the pallet *p* is just raised clear of the tooth s, while the pallet *q* is brought down, so that a tooth is caught on the *inner* sloping face, just at the obtuse angle formed by that face and the plain part of the hook, as is seen in the figure. While the pendulum is advancing to complete the oscillation, the flat edge of the tooth slides on the plain part, and as this is part of a circle described from the axis of the arbor at A as a centre, the wheel is unmoved by the pallet during the time taken by the pendulum to complete that remaining portion of its oscillation. When the oscillation in the contrary direction, or to the left, has brought the pallet G back, so that the point of the same tooth presses on the sloping face of the pallet, the action of the weight causing the wheel to move onwards with a certain force, the tooth in sliding over the slope acts on this like a wedge, and tends to increase the velocity of the arc; and this pressure is adjusted so as to restore to the pendulum that force which it would otherwise lose by friction and resistance of the air. While the tooth is passing along the face of *q*, S has passed on so as to allow the pallet *p* to come between the teeth *s* and *v* in its advance to the left, caused by the swinging of the arc. When *q* is removed out of the way of the tooth, this is carried on clear of it, and the wheel, unrestrained, turns on till *v* strikes on the *outer* obtuse angle formed by the sloping face of the pallet and the outer plain part of the hook. This happens, as before, a little previous to the completion of the oscillation, and during this small remaining portion of motion to the left, the outer face of *p* slides on the straight edge of the tooth *v*, without causing any recoiling motion in the wheel. The oscillation to the right now recommences; the point of the tooth *v* begins to slide over the sloping face of *p*, and in so doing gives an impulse to the arc, and through it to the pendulum, sufficient to counteract the effects of friction and resistance, till *v* passing off the inner point and clear of the pallet, the wheel advancing, brings the tooth W to strike on the inner angle of *q* as before, and the same reciprocating action is repeated.

The wheel, by this action of the pallets, moves in a continued direction from right to left, by small, equal portions of its circumference, in sudden jumps, each equal portion of this motion being accomplished in each equal portion of time occupied by a oscillation of the pendulum; and at the same time the wheel, by its alternate pressure on the pallets, restores the force of the pendulum, and thus the equality of its arc of vibration.

It has been mentioned that it is the *continuous* action of gravity which causes the unrestrained weight to descend with an accelerating velocity; but as this action is stopped at each oscillation of the pendulum for the moment that each tooth of the wheel is resting on the plain faces of the pallets, gravity recommences each time a tooth is set free, so as to allow the wheel to move on with the *same* force; since it is known that the force of gravity is always the same on any body moving through the small space the weight of a clock has to descend through. Consequently, since gravity acts on the weight with equal power after each suspension of motion in the wheel, it always communicates an equal velocity to this, and therefore again causes the wheel to act on the pendulum with an equal power each oscillation.

The swing-wheel and pallets together constitute what is called the *escapement* of a clock, and as the degree of accuracy with which the machine *goes*, mainly depends on this part of it, to improve, or perfect, the escapement movement of clocks has exercised the science and practical skill of mathematicians and mechanists since its first discovery. A brief account of the principles on which the different species of escapements are constructed will be hereafter given, when we have finished the general description of the rest of the wheel-work of a clock.

It will be next necessary to show how the essential parts above described are put together in practice, in order to move two hands on a dial, or clock-face, so as to point out the passage of equal portions of time, as it is divided at present into days of twenty-four equal hours; and then the mechanism by which the equal intervals of hours are struck on a bell will be explained, so as to cause the passage of time to be *heard* as well as *seen*. To simplify this description, the wheel-work belonging to the last-named part will be shown in a separate figure, for though it is included in the same frame as the ordinary movement in all clocks, yet it is distinct from, and independent sufficiently of, that movement to admit of its being explained apart.

It is also necessary to state that perhaps no clock is constructed just as it is here described; for the purpose of explaining general principles, methods of effecting the objects of different portions of the essential mechanism, are supposed to be adopted in the same clock, which are not actually so combined; in some particulars our imaginary clock will be no better than a common Dutch clock in a kitchen, while in others it will resemble the best clock employed in an observatory.

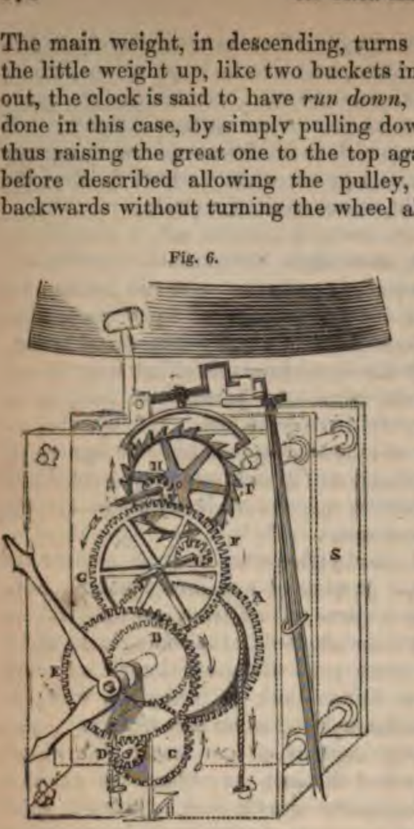
The frame of a clock usually consists of two rectangular brass plates, kept together at the requisite distance by pillars one at each corner; the *arbors* or axles of the various wheels turn in holes in these plates: it is therefore essential that the plates should be truly parallel to each other, and the arbors correctly perpendicular to them, for otherwise the wheels would not turn easily on their axles; in order also that the wheels themselves should turn round in one plane, they must be also perpendicular to their arbors, for if they were not, two wheels which worked together would grind and wear their teeth, and destroy their correct action.

If the clock has a *striking movement*, intermediate plates or bars are required to support the axles of the accessory wheels; but it may be easily conceived that the form and arrangement of these plates is a matter of secondary importance, and do not require description here. In the following figures these plates, frames, and pillars are only indicated by dotted lines, to allow of the wheels being more distinctly shown.

In common clocks with pendulums, instead of the cord supporting the weight being wound several times round a barrel as before described, it is simpler to have it pass, once only, over a pulley at the back of the first wheel A; notches are cut, or pins inserted, in the groove of this pulley to prevent the cord slipping round it, and allowing the main weight to fall to the ground: to the other end of this single cord a small weight is tied, which, by keeping the free part of the cord stretched, prevents it from becoming entangled with that sustaining the weight.

The main weight, in descending, turns the pulley and wheel, and draws the little weight up, like two buckets in a well; when the cord is drawn out, the clock is said to have *run down*, and to want winding up, which is done in this case, by simply pulling down the little weight by hand, and thus raising the great one to the top again: the ratchet-wheel and click before described allowing the pulley, like the barrel, to turn round backwards without turning the wheel along with it

Fig. 6.



A is the first great wheel, with the pulley on its arbor for the cord of the weight; the ratchet-wheel and click is omitted for a reason hereafter given; the cord is seen going round the pulley, but the weight is not shown from want of room: the direction of its descent is indicated by the arrow near the cord. The wheel A turns round once in an hour: its arbor passes through a tube, or *pipe*, on the squared end of which the minute hand is put; the arbor of A fits sufficiently tightly into the pipe to carry it round with it by means of friction, and yet the two being separate admits of the pipe being turned round with the minute-hand, so as to *set* or adjust the clock, without turning the wheel A along with it.

The tube or *pipe*, just mentioned, serves as the arbor to a small wheel B, which acts on an *equal* one C, on the arbor of which is a *pinion* D, which gives motion to the wheel E, through the hollow axle of which the pipe of B and the solid arbor of A pass: E is turned round once in *twelve* hours, and the hour-hand is put on its arbor. By following the directions in which these five wheels and pinions turn, as indicated by the arrows, it will be seen that the hour and minute-hand revolve in the same direction from left to right in front of the dial, but this dial is supposed to be removed in the figure, as it would conceal the works. The wheel A also turns the pinion F, on the arbor of which is fixed the wheel G; this again works the pinion H on the arbor of the *escapement*, or *swing*, wheel I.

Before proceeding further, it must be mentioned that there are two conditions which determine the number of teeth in the wheels above-described,—the length of the pendulum, and the time the clock is to go without wanting winding up; and these again depend on the proposed size and situation of the clock. It is well known that the longer a pendulum is, the slower it oscillates, and the shorter it is, the more rapid its oscillations; and this variation follows a simple uniform law. A pendulum, for example, three feet long, makes one vibration in a second[*]: another to vibrate *twice* in the same time must be only *one-fourth* as long, or nine inches; and a pendulum *one-ninth* as long, or four inches, would vibrate *three* times in a second, *the number of oscillations being inversely as the square roots of the lengths of the pendulum.*

Now, though the longer the pendulum the better the clock will go, generally speaking, yet on many occasions it is impossible to have a long one; and then to compensate for the increased rate of motion of a short pendulum, there must be more teeth in the wheels, or even more wheels, otherwise the weight would run down too soon.

Or if it were required that the clock should go a longer time without wanting winding up, the wheels must have more teeth, and these must consequently be larger; or if the size of the clock does not admit of this, then extra wheels must be added, and this must be done if there is not room for the weight to descend low enough to obviate the necessity of frequent winding up.

In the clock which we are describing, the wheel A has 64 teeth, and turns round once in an hour, carrying B, and therefore C and D of course, once round in the same time: D has 6 teeth or *leaves*, as those of pinions are called; D therefore must turn twelve times round to make E, the hour-wheel, turn once: E consequently has 72 teeth.

But in clocks intended to go eight days without winding up, the first wheel, A, has 144 teeth, and E 160; and if the clock were to be constructed to go 200 days, the first wheel, A, must have 180, and E 200 teeth, and at least one extra wheel must be introduced to effect the purpose.

In some clocks the escapement-wheel is calculated to move round once in a minute: in this case it generally carries a *second hand* at the end of its arbor, which is continued through the dial-plate for that purpose, as is shown at H in the figure, p. 378, but of course when this is done, this *second hand* is not concentric with the two others, but moves round a small divided circle painted on the dial expressly for it.

We shall now proceed to explain the mechanism of the striking part, and though shown in a separate figure here, it must be understood to be included in the same frame as the former part, and as lying in the space S (see former figure) between the back and middle plates of the frame.

The wheel K is turned round by means of another weight hanging to a cord passing over a pulley at the back of K; it is, therefore, so far, quite independent of the wheel-work already described: the weight turning K is wound up in the same manner as the other weight is, but the motion of K is governed by the other part of the works by the following arrangement. At the back of the wheel *c* (see next figure) is a projecting pin, which, at every revolution of *c*, that is, every hour, is brought to press against an arm *l*, carried by a long arbor, *m*, on which there is another arm, or *detent*, *n*: *n* is therefore raised up when *l* is raised by the pin on the wheel C. At the same instant *n* is raised, it raises another detent *o*, fixed to an arbor, *p*, carrying two other detents, *q*, *r*; *q* has a small hammer-head, which passes into a notch in a hoop-ring fixed in front of the wheel, M; *q*, by this contrivance, prevents M from being turned round, in consequence of the action of the weight on K: and *r* in a similar manner, by means of its bent extremity, which catches in notches in the circular plate fixed to the *count-wheel*, N, also restrains the *train* of wheels from being acted on by the weight.

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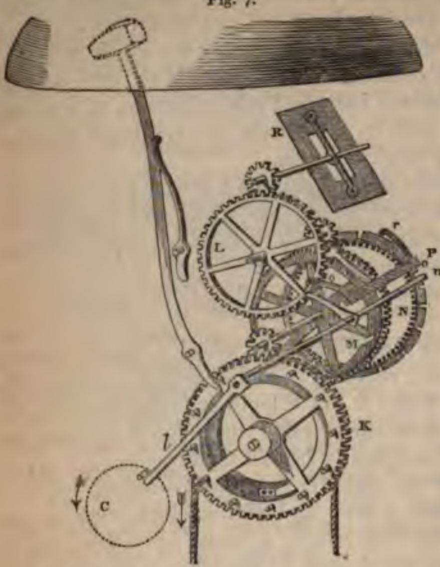
[*] The length of the pendulum to vibrate seconds, as it is called, varies a little according to the latitude of the place; it must be longer at the equator than at the poles. In the latitude of London the *length of the seconds' pendulum* is 39·14 inches, or a little more than a yard and three inches; and the pendulum which would vibrate seconds, or perform 86,400 oscillations in a day, at the equator, would complete about 86,550 at London, and 86,628 at the pole.

Fig. 7.



When *l*, and consequently *n*, are raised by the pin on *c*, the detents *q* and *r* are freed from the respective notches in which they were engaged; the weight, by its action, turns K round, and a pinion on the arbor of that wheel turns M; the arbor of M has a pinion on it, acting on L, and this wheel again turns the pinion on the arbor of the *fanner*, R; this fanner is a *regulator*, consisting of a light, broad, brass fan, which, by the resistance of the air when it is rapidly revolving, prevents the train of wheels from moving too fast, or, in short, *regulates* their velocity when they are otherwise abandoned to the unrestrained action on them of the weight.

But when the detent *n* is raised to a certain height, it meets a pin on the front of the wheel L, and thus stops that wheel, and consequently all the rest; it is the noise of this sudden check which is heard a few minutes before the clock strikes the hour, and is called the *warning*. During the short time the train of wheels were in motion, M and N have turned a sufficient part of a revolution to remove the notches from under the detents *q* and *r*; when the pin on *c* has moved on, by the regular going of the dial-work, so as to leave the detent *l* at liberty, *n*, *p*, *q*, and *r*, drop down again, *n* leaving the pin on the wheel L free, and the others, instead of having the notches to drop into, fall on the plain part of the ring and edge of the plate. The weight, being therefore once more unrestrained, sets the wheels and fanner in motion again: there are twelve pins, seen on the near face of the wheel K, each of which, as that wheel revolves, catches the end of a lever having a hammer-head, and thus forces this back; when the pin has passed, leaving the lever free, a spring, also seen in the figure, acts upon the hammer, sending it smartly against the bell, or the clock *strikes:* this action is repeated until *r*, sliding on the edge of the count-wheel-plate, meets a notch, into which it slips, and so stops the motion of the train of wheels.

The number of times the hammer strikes the bell is regulated in the following manner: the count-wheel N has seventy-eight teeth, and the notches in the plate attached to it are at the distances of 1, 2, 3, 4, 5, &c. teeth apart in succession. It will be found that this series of numbers up to 12 inclusive, added together, make seventy-eight: the count-wheel N is turned by a pinion of twelve leaves on the end of the arbor of the pin-wheel K, and the number of teeth in the rest of the train is so adjusted and calculated, that at one o'clock, the shortest space, equal to one tooth, on the plate, passes under the detent *r;* only one pin on the wheel K has, therefore, time to catch the hammer-tail, before the motion of the train is stopped again by *r* falling into the next notch. At two o'clock, the space on the plate equal to *two* teeth on the wheel N passes under *r*, and the wheel K has time to turn round sufficiently to admit of *two* pins catching the hammer-tail, and the bell is struck twice, or two o'clock; and so on for each hour in succession, till, at twelve o'clock, the last and longest space on the edge of the plate, equivalent to twelve teeth, passes under the detent *r;* the wheel K making a complete turn, all twelve pins act on the hammer before it is stopped by the detent falling into the first notch again.

This is the *striking* mechanism employed in the common Dutch wooden clocks, so common in our kitchens and cottages. In the better kind of clocks, however, a different method is adopted, which will now be described, called the *rack and snail* striking work.

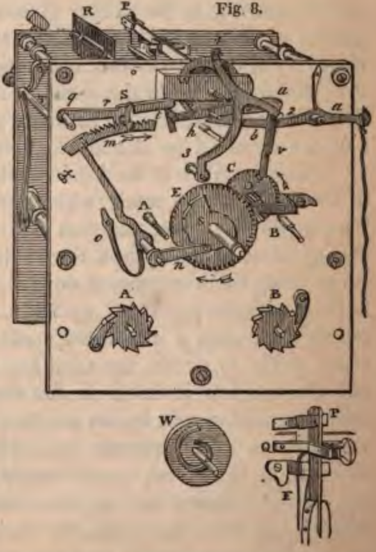


Fig. 8.

The adjoining figure shows the various wheels, &c., lying immediately under the dial, and in front of the outer plate of the frame, of an eight-day clock*, and will not only explain the mechanism in question, but will throw a light on the other parts that could not be shown in the former views.

C, D, and E, are the wheels corresponding to those similarly lettered in the two preceding figures; E being that which carries the hour-hand on its pipe-arbor; C moves an equal wheel behind E, on the squared end of the arbor of which is fixed the minute-hand, as has been before described. The *snail*-wheel, S, is pinned to the face of E; this snail is cut at its edge into twelve successive steps, which occasions the spiral form whence its name is derived; each step subtends an equal angle at the centre of the snail, their diminution in width being only occasioned by their being successively nearer and nearer to the angular point: consequently one step moves on regularly every hour as E revolves in twelve: a pin on the inside of the arm *n* presses against the step, or into the angle of each, in succession, as they pass by.

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* The figure is copied from Rees's Cyclopædia.

The other arm of the lever *n* carries the *rack m*, it being all of one piece, and turning on a centre seen near the wheel E; *o* is a spring which acts against a projecting tail of the straight arm of *m*, and by so doing keeps the pin in *n*, before mentioned, close up to the step of the snail: this spring, it will be seen, would, by its action, therefore, turn the rack round from right to left, if the snail and pin did net prevent this: *x* is a fixed pin in the frame-plate, against which *m* falls when the rack is at its furthest position to the left.

A wheel, corresponding to that lettered M in the former figure, but not seen in this, from its being behind the frame-plate, has the piece S, called the *gathering pallet*, fixed at the end of its arbor, which comes through the plate for that purpose; at every revolution of this wheel caused by the *train*, a catch in S lays hold of a tooth of the rack, and moves it in the direction of the arrow, till the pin seen on *m* comes in the way of the longer end of S, which, by striking against the pin, stops the motion of the wheel; and also that of the pin-wheel K (see fig. 7, p. 380). The pins on the face of this last mentioned wheel act on the arm T, which carries the hammer-head for striking the bell; and the spring which sends the hammer back against the bell to produce the sound, is shown in the figure as pressing against a pin in T for that purpose: *p r* is a lever turning on its centre at *p*, and carrying at *r* a *catch* with a sloping end, called the *hawk's-bill;* this catch admits of the rack *m* moving in the proper direction, but prevents its return, in consequence of the ratchet form of the teeth of *m*, till the end of *p r* being raised by *t*, the hawk's-bill is disengaged from the tooth of the rack which it retained, and then the spring *o* sends *m* in the contrary direction to that of the arrow, leaving as many teeth of the rack to be gathered up by S as are required for the hour about to be struck.

This number of teeth of *m* which are thus left, is governed by that of the steps of the snail which have passed since twelve o'clock struck last, in the following manner: while the first step of the snail, that at the greatest distance from the centre, is moving over the pin in *n*, this lever being thereby pressed downwards to the greatest extent, the rack *m* is held with its pin close up to S, and could not, consequently, move either way, even if the hawk's-bill were freed from it; but before the clock ought to strike, the snail has crept round till the first step passes the pin and lets it down on the next step; the spring *o* now forces *m* back towards *x*, and leaves *one* tooth of the rack to be gathered up by the pallet S. In the mean time, the arm *t* has been raised by means of the pin on the wheel *c*, sufficiently to disengage its inner end from the pin on the wheel L (see fig. 7, p. 380), but yet not so much as to free the hawk's-bill from the rack; the train of wheels now moves on for a turn or two by the action on it of the weight, and thus gives warning. When the piece *p r* is raised still higher by *t*, the rack is freed, and it falls back for the space of one tooth, as was above explained: a minute or two after the pin on *c* passes the end of the arm *v*, and leaves it free, consequently *t* falls by its weight, a slit being made in the plate for that purpose, and leaves the wheel L unrestrained, when the train moves on till *m* (see fig. 7, p. 380), having made one turn, the pallet S gathers up the one tooth of the rack, and one pin of the pin-wheel K catches the hammer-tail, and the clock strikes one; S is immediately caught by the pin on *m*, and the train stopped till the next hour.

A little before two o'clock, the wheel C has brought the pin on it round again, and this pressing against *v*, *t* is again raised, and the clock gives warning; the snail S has then turned so that the *second* step has passed over the pin, and allows *m*, when freed from the hawk's-bill by the rising of *t*, to fall back *two* teeth: the pin on C quits *v* as before, *t* falls, leaving the wheel-work free to turn, two pins of K have time to act on the hammer before S gathers up the *two* teeth, and then the motion is stopped again.

This action is repeated each hour in succession; each time the rack *m* falling back an additional tooth, in consequence of the snail having passed an additional step over the pin, and thus, by its spiral form, allowing the end of the arm *n* to rise higher, or nearer the centre of E, so as to admit of the additional motion of the rack on its centre. Just before twelve o'clock returns, the snail is moving its lowest step over the pin on *n*, so that the rack can fall back for the space of all its twelve teeth till *m* rests against *x*, and all twelve being gathered up by S, all twelve pins on K act on the hammer before the train is stopped by S striking against the pin on *m*. The sloping straight part of the snail, by acting as an inclined plane on the pin, raises the rack back to its original place to recommence the same succession of actions.

It will be easily perceived, that at any time, between two strikings on the bell, till the snail has moved so as to admit of the rack falling back an additional tooth, if the hawk's-bill be raised by *t* being raised, and the wheel-work thereby set free, that the last number of hours struck will be struck over again. An arm *a b*, turning on a centre, has a string attached to one end, while the other, *b*, will raise *t*, by means of a pin on *t*, against which *b* presses, if the string be pulled; and by this means, the hawk's-bill is disengaged from the rack as was mentioned. This simple contrivance converts the clock into a *repeater*, so that a person, by pulling the string in the dark, can tell what hour passed last.

The words "strike," "silent," are seen on the dials of many clocks, indicating that the action of the striking part can be suspended at pleasure for any time, and renewed again, by means of a contrivance now to be explained.

The irregular-shaped three-armed piece 1, 2, 3, turns on a centre at 3; the pin on the arm 1 comes through an arched slit in the dial, so that, by pushing the pin by hand, the piece can be moved either to the left or to the right; the back of the arm 2 is shaped to an inclined plane, like a wedge, so that, when 1 is moved in one direction, this wedge, by pressing on the end of the arbor, on which the warning-piece *t v v* turns, pushes it in, so as to throw the arm *v* out of the reach of the pin on the wheel C, which then passing without touching *v*, the striking train remains unacted on, and the clock does not strike, or is *silent*. The arbor of *t v v* is made to rest in its sockets, so as to admit of being thus pushed in, and a spring, by pressing against a collar on that arbor, forces it out again when the wedge 1 is removed by pushing its pin the other way; the arm *v* is, by so doing, brought again within the influence of the pin on C, and the striking works act again, or the clock *strikes*. The contrivance for effecting this purpose varies greatly in different clocks, but this description will explain in what manner the object can be effected.

Our clock, thus provided with a striking mechanism in addition to its principal works, though sufficiently complete for the purposes of domestic life, is far from being perfect enough, if it were required to be an accurate time-keeper; however beautiful the workmanship of it might be, it is defective in two particulars.

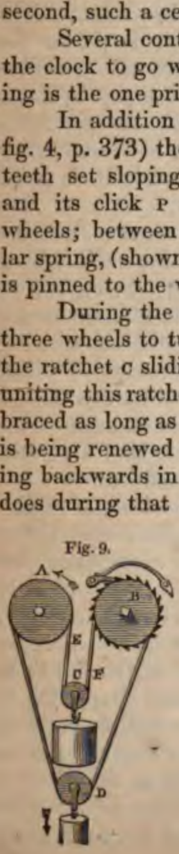
Though the ratchet-wheel and click, described p. 373, admit of the clock's being wound up without turning the wheel-work backwards, yet it is obvious that, while the weight is being so raised, it must cease to act on the train, and that therefore, during the time this occupies, the motion of the works must stop; now, although this short period is of no consequence on ordinary occasions, yet in clocks intended for astronomical purposes, where the time must be measured truly to the tenth of a second, such a cessation of the movement would be fatal to the object.

Several contrivances have accordingly been invented for enabling the clock to go while the action of the weight is suspended; the following is the one principally in use in portable time-keepers.

In addition to the ratchet-wheel and click, already mentioned, (see fig. 4, p. 373) there is added another larger ratchet-wheel C, having its teeth set sloping in the contrary direction to those of the first wheel F, and its click P screwed to the clock frame quite independent of the wheels; between this ratchet C and the wheel A there lies a strong circular spring, (shown by dotted lines in the figure,) one end of which spring is pinned to the wheel A, and the other to the ratchet C.

During the going of the clock, the moving power causes all these three wheels to turn together in the direction of the arrow, the teeth of the ratchet C sliding freely, unchecked by the click P; the circular spring uniting this ratchet to the first toothed wheel A, and being itself constantly braced as long as the moving power is acting. When the moving power is being renewed or wound up, the click P stops the ratchet C from turning backwards in the contrary direction to the arrow, as the former F does during that operation, and this ratchet C, by being thus stopped, forms a fixed basis for the one end of the circular spring to act from, while the tension of the spring, arising from the moving power, being now suspended, in its effort to expand, it urges on the wheel A in the same continuous direction, without any interruption to its motion.

Fig. 9.



Another ingenious mode of accomplishing the same purpose was the invention of the celebrated mathematician, Huygens, who lived at the commencement of the last century (see fig. 9.).

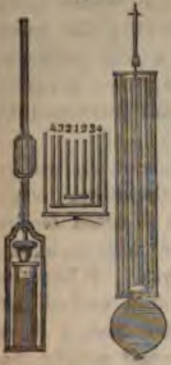
A is the pulley at the back of the first wheel of the *going* or *dial-work*, as described p. 378, but this pulley, instead of having any ratchet-wheel, is *fixed* to the toothed wheel, so as to be incapable of any motion separate from that of the wheel; B is another pulley, having a ratchet-wheel and click, the whole being attached to the framework of the clock quite independent of the train. An endless cord passes round these two pulleys, round a free pulley C, to which the weight is hung, and also round another free pulley D, carrying a small weight, for the purpose of keeping the cord stretched to prevent its entangling.

While the clock is going, the ratchet and click prevent the pulley B from being turned round by the weight; this weight, therefore, hangs from B as from a fixed point, consequently, the pulley A is acted on by half the weight of the *weight*, which must accordingly be twice as heavy as it would be required to be if acting in the usual way. When the clock is to be wound up, the key is applied to the squared end of the arbor of B, and as by this winding up B turns round faster than A does by the motion of the train, the weight rises, while the small weight, by descending, keeps the superfluous part of the cord, which passes over B during winding, stretched tight. Now, it will be seen that the act of turning B round by the key does nothing to relieve A from the half of the weight it supported; accordingly, A is still acted on by that half weight, and its motion is uninterrupted. If the pulley B, with its ratchet, instead of being an independent fixture, were attached to the pin-wheel K (see fig. 7, p. 380) of the striking part of the clock, it is obvious that the action of the weight would be the same on A in the intervals between the hours as has been above described, and that the half weight of the weight supported by B, as from a fixed point, during those intervals, would be competent to turn the striking train of wheels when abandoned to its action. One double weight, with an endless cord, would be sufficient for both parts, instead of two single weights being employed; this is accordingly done in many clocks of a better construction than the commonest sort, and it is for this reason that the pulley on the wheel A, in the figure p. 378, was shown and described as having no ratchet-wheel to it.

The most requisite essential to perfect a clock is a contrivance to obviate the effects of change of temperature on the pendulum. It has been already stated that the longer a pendulum is, the slower its vibrations, and the reverse; now, as all substances expand by an increase of heat, and contract by a diminution of it, it is clear that the rod of a pendulum would lengthen or shorten according to the increased or diminished temperature of the air or surrounding bodies, more especially if the rod be of metal. This change in length would affect the rate of going of the clock, and, besides partial variations, a clock would uniformly lose in summer and gain in winter.

There are several contrivances by which the distance from the point of suspension of a pendulum to the centre of its weight, or *bob*, is preserved constant in all temperatures, and all founded on the different degrees in which different metals expand or contract when exposed to the same changes of temperature; we shall only describe two *compensation pendulums*, as they are termed, which are chiefly employed in the finest clocks made for observatories. Instead of the bob of the pendulum being hung by a single rod, a frame composed of *nine* parallel rods, as seen in the annexed figure, is used; these rods are put together in the following manner:—the central rod is of *steel*, and to the top of it is pinned a piece of watch-spring, by which the pendulum is hung; at the lower end the rod has a short horizontal cross-piece, which supports a *brass* rod on each side of the steel one; these two rods are not so long as the steel rod, and are joined together at top by another cross-piece, which has a hole in the middle, through which the first rod passes; this cross-piece projects beyond thebrass rods, so as to allow of another steel rod on each side being hung from it; these two are a little longer than the brass rods, and therefore hang lower down, so as to allow of their being joined together at bottom by another cross-piece again, which, by projecting on each side beyond the steel rods, serves as a support to two more *brass* rods, and these again are united at their tops by a similar cross support, from which descend the two outermost rods, which are of *steel;* these, descending lower than the adjoining brass rods, are united by a cross bar, from the centre of which hangs the *bob* of the pendulum.

Fig. 10.



Brass is known to expand more than steel by an equal addition of heat; when, therefore, the steel rods elongate *downwards* by the effect of an increased temperature, which would lower the bob, or *lengthen* the pendulum, the brass rods being all supported at their lower extremities, by their superior proportional expansion lengthen *upwards* sufficiently to keep the cross piece to which the bob is attached at the same constant distance from the point of suspension in all changes of temperature; for the reverse of these reciprocating actions takes place on a diminution of heat. The lengths of the various rods and the proportions of the four outer ones on each side to the longest or central rod, are all adapted, by accurate experiments and calculations, to produce this effect of *compensation* for expansion or contraction in the suspending rod of the pendulum.

This beautiful contrivance was the invention of J. Harrison, a carpenter, mechanist, and clock-maker, at Lincoln, in 1700; and this pendulum, from the general appearance of its bars, is called the *gridiron pendulum.*

In 1715, Graham, a clock-maker, to whom we are indebted for several important improvements in clocks and watches, and whose name will be mentioned again in describing some of these, invented another compensation pendulum on the following principle. The rod of the pendulum is a plain single steel bar, formed at its lower end into a rectangular *stirrup* (see last figure), the bottom of which is a circular plate, on this is placed a cylindrical covered *glass* jar, or bottle, filled to a certain height with *mercury*, this jar constituting the weight or bob. When, by increasing temperature, the steel bar lengthens, the mercury, which metal is considerably affected by change of temperature, *rises* in the glass vessel, and by so doing, raises the *centre of gravity* of the mass, so as to *compensate* for its depression occasioned by the lengthening of the steel. There is another mechanical point in a pendulum, called, scientifically, the *centre of oscillation*, on the distance of which from the point of suspension the effective length of the pendulum depends; now, these two points are so connected, that, when the *centre of gravity* is changed, the other varies with it; and conversely, if the former is preserved constant, the effective length of the pendulum remains unchanged. The quantity of mercury in the jar is varied till the desired effect is found by repeated experiments to be accomplished.

One or other of these two species of compensation pendulums, though modified in the details of their execution, are employed in the construction of the finest astronomical clocks both here and abroad.

When the works of a clock are put together, the correct length of the pendulum must be ascertained by trial; if the clock gain regularly every day, it shows that the pendulum is not long enough; there is a screw underneath the bob, by means of which this can be raised or lowered on the rod; after the bob has been lowered a little, the trial must be repeated, and if the pendulum were lengthened too much, the clock would *lose* regularly, and the bob must be screwed up a small quantity, and so on till it is found that the clock goes correctly with the sun, allowing for the inequality of the motion of the earth. When the correction is made, if the pendulum be a compensating one, the clock will not require any further regulation, but if the pendulum be one of the ordinary kind, then the pendulum will want adjusting from time to time, to adapt it to the variations of the temperature, according as the clock is found to gain or lose irregularly.

In the better kinds of clocks for domestic use, which are never furnished with a compensating one, there is an ingenious contrivance for lengthening or shortening the effective length of the usual pendulum: W is a small circular plate (see fig. 8, p. 381), having a spiral slit in it, and is turned round by a key; the pendulum hangs by its piece of watch-spring from one end of an horizontal lever, which turns on pivots supported between the front and back plates of the clock frame, the other end of the lever terminates in a pin, which passes into the spiral slit before mentioned. When the plate is turned round, the form of the slit causes it to *raise* or *depress* the end of the lever, and therefore *depresses* or *raises* the opposite end, and with it the pendulum. The watch-spring by which this hangs is clipped between two pieces of brass *screwed* to the back-plate; when, therefore, the whole pendulum is drawn up or lowered by the lever, it shortens or lengthens the distance between this fixed point and the centre of the bob, and thus the effective length of the pendulum is changed.

It is essential to the correct action of the pendulum and escapement, that the oscillations of the former should be to equal distances on each side of an imaginary central plane, dividing the clock into two equal parts. This is effected by setting the clock up in its place, so that this central plane may be truly perpendicular to the horizon. If this precaution were not taken, the pendulum, by vibrating further to one side than to the other, would cause the escapement-wheel to act unequally on the pallets, and in return to be unequally acted on by them, which would affect the going of the clock and injure the works. When a clock is not set up truly, so that this unequal action takes place, the *ticking* of the clock is alternately strong and weak, owing to the teeth of the escapement falling on the pallets with different degrees of force instead of equally; the clock is said to be *out of beat*, and the defect must be remedied by levelling the stand supporting the case, or setting the case perpendicular, if it be a hall clock.

Clock-makers have, at all periods, exerted their ingenuity in contrivances for causing their clocks not only to strike the hours, but even the half and quarter hours, play chimes or tunes, show the moon's age and phases, the times of high water, and many astronomical phenomena. When these are of regular occurrence at *equal* intervals of time, they are easily indicated on the dial by the simple addition to the train of the requisite number of extra wheels and pinions, as *any* regular motion in any velocity can be produced by such means as has been already mentioned; but when the phenomena to be recorded are *irregular* in their recurrence, more complicated mechanism, consisting of what are termed *eccentric movements*, is required.

The elliptic orbit of the earth, and the inclination of the plane of the equator to that of the ecliptic, or earth's orbit, causes the time between the return of the sun to the same meridian to vary every day of the year. The return of the sun to the meridian indicates what is termed *apparent noon*, while the hour of twelve on a good clock constantly recurring at the same interval of time, and therefore affording a *mean*, as it were, during the year to the *apparent* time, as shown by the sun, is called *mean noon*, or the clock is said to keep *mean time*.

The difference between the time of the sun's return to the meridian and the hour of twelve by a good clock, is called the *equation of time*. This difference can be and is calculated from astronomical observations and the mathematical principles deduced from them, for every day in the year, and is given in all *tables* and almanacks. By means of these tables all clocks are regulated from observations on the sun, so that a year by the clock of 365 days 5 hours shall exactly agree with that epoch as shown by the heavenly bodies, though the clock and the sun vary at all other times, or at least only agree at four periods during the year.

It was a favourite object with clock-makers of former times to construct clocks that would keep *apparent* as well as *true* time; such clocks were called *equation clocks;* and to effect this, comparatively complex eccentric motions were required to be added. A mechanic of the name of Enderlin contrived equation movements to a clock, which showed, besides apparent time, the sign and place of the sun in the heavens, the hours of its rising and setting, the months of the year, and many other things.

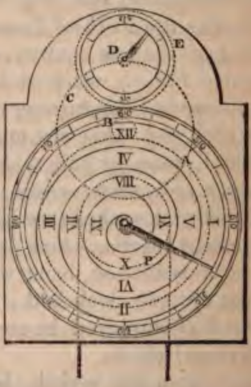
All these additional works are serious injuries and drawbacks to the effecting the aim of all clocks or time measurers, that of *true and constant motion*. It is obvious that the more complicated any machinery is, the greater the friction to be overcome by the moving power, and the more liable to derangement it consequently becomes, and the more irregular its action at all times, owing to the necessary imperfection of even the best workmanship. With increasing knowledge and skill therefore, it has been the constant object of our best modern clock-makers to simplify as much as possible the works of a time-keeper, and at the present day no striking works even are ever admitted in astronomical clocks; the simplest works with the plainest dial being put into simplest cases, while the real beauty of such a machine, that which excites the admiration of the man of taste and knowledge, is the superior theory of the escapement and compensations, and the superior accuracy and finish of the workmanship.

If a clock keep regular *mean time*, it is clear that it is a much easier, ultimately, because a more accurate mode of proceeding, to refer to a printed set of tables for the time of high water, the moon's age, &c., &c., than to consult a clock indicating these phenomena, which is perpetually being deranged in its action from the complexity of its movements: all such useless works, whatever ingenuity they may evince in their contrivance, and whatever admiration they may excite in the minds of illiterate people, are entirely banished from any clock intended for a better purpose than that of ornamenting a drawing-room or of amusing some barbarous eastern despot, as the King of Bantam or the Emperor of China.

Since the more simple any machine can be rendered, the *cheaper*, as well as the less liable to derangement, it can be made, and consequently available to a greater number of persons, it has been the object of several scientific mechanists to contrive clock movements with the fewest wheels; and it must be understood, that it requires more knowledge and thought to simplify a piece of mechanism so as to dispense with one or more wheels in it, than it does to accomplish any proposed action by the addition of new ones.

James Ferguson, the celebrated astronomer and mechanist, contrived several clocks with simple movements, one of which showed the seconds, as well as the hours and minutes, and required only three wheels and two pinions.

Fig. 11.



We shall describe a clock, equally simple and effective, invented by Dr. Franklin: the adjoining figure represents the dial; the wheels behind are shown by dotted circles, there being only three required. The large wheel A has a pulley, with its ratchet and click attached to it, round which the cord supporting the weight passes as usual; on the arbor of the first wheel is placed the hand which serves to indicate the hours and minutes. A is worked by a pinion B on the arbor of a wheel C, which receives its motion from a pinion D on the arbor of the escapement wheel E. The pendulum vibrates seconds, and since E has thirty teeth, it revolves once in a minute: its arbor carries the second hand shown in the figure. The pinion D has eight leaves and the wheel C 120 teeth, consequently this last turns round once in *fifteen* minutes, or a quarter of an hour: B has ten leaves, and A 160 teeth; this first wheel, therefore, revolves once in sixteen quarters of an hour, or in four hours.

The outer circle on the dial is divided into 4 × 60 = 240 minutes, and within this there is a spiral line on which the hours are marked, at the points where two diameters, at right angles to each other, cut the spiral; these diameters, therefore, divide the circle into four parts of sixty minutes, and each turn of the spiral into four parts, or into hours.

In the figure, the hands point to — minutes and — seconds past, either *one*, *five*, or *nine* o'clock; and no one can be mistaken as to which of these is the true hour in the longest summer's day or winter's night. If such a clock be well made, have a compensating pendulum, a good escapement, and Huygens' extra detached ratchet (see p. 384), it would be as perfect in action as the clocks with more complicated works.

It has been shown, by the description of the clepsydra, that toothed wheels were employed in machinery before the Christian era, and that complicated instruments for measuring time were made with them, falling water being the *moving power:* the substitution of a *weight*, requiring only to be raised up again in order to renew its action, was a great improvement: the precise period when this was made, like that of most useful inventions, is a matter of doubt, probably because such inventions are always the result of several prior imperfect attempts, of which no record was preserved.

Pacificus, archdeacon of Verona, in 850; and Gerbert, afterwards Pope Sylvester the Second, in 999, are said to have constructed *clocks*, in the usual sense of the word: but considerable doubts are entertained whether these were not only clepsydræ, or even only sun-dials, so vague is the description of them. And the instrument called a clock, supposed to have been made in 1326 by Richard Wallingford, of St. Albans, was probably an orrery for showing the motions of the planets.

Though it is possible, or even probable, that true clocks were made in various parts of Europe previously, the first of which any certain account exists was that constructed in 1364 by Henry de Wyck, for Charles the Fifth of France. This clock was in existence at the beginning of the last century, and was examined by Julien le Roy, the celebrated French watch-maker: the *regulating power* of Wyck's clock was a horizontal bar turning on a central pivot, and carrying an equal weight at each end; this was made to swing backwards and forwards, in a horizontal plane, by pallets on the perpendicular arbor of it, acted on by a *crown escapement wheel;* something in the manner of that escapement hereafter described (see Escapement), only it had no spring, the *equal* and constant inertia, which it had to overcome at the commencement of each return-oscillation, being the retarding power to the descent of the weight. This antique clock had a count-wheel striking part, precisely the same as that still employed in our present Dutch (or, more correctly speaking, German) clocks.

From this period, clocks were erected in most great towns. Strasburg possessed a clock as early as the year 1370; though the celebrated clock of that place, which is still in existence, was not set up till the year 1570—1[*].

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[*] For an account of the clock of Dasepodius, see *Saturday Magazine*, No. 34.

Unfortunately, the accounts of the clocks of these earlier times were written by persons who were more struck with the fantastic devices and useless movements with which they were encumbered, than capable of understanding or appreciating their comparative mechanical and theoretical excellence: hence no useful accounts exist, by which we might judge of the progressive improvements in this important art.

The oldest English clock now extant is that in a turret of the palace of Hampton Court; it was constructed in the time of Henry the Eighth: the initials, N. O., on it, are supposed to be those of the maker, but nothing is known concerning him.

By whom and when the pendulum was first applied as the *regulating power* to a clock is quite unknown: it has been even asserted that it was used by the Arabians for the purpose at an early period; while others maintain that Justus Berge, a Swiss, was the first clock-maker who applied a pendulum to a clock, in 1552. Huygens also laid claim to the merit of this invention, and there is extant an account tending to show that this honour is due to an Englishman, one Richard Harris, who, in 1641, made the first pendulum clock for the old St. Paul's church in Covent Garden. Galileo only discovered the property of the pendulum in 1639.

[To be continued.]

A POPULAR COURSE OF CHEMISTRY.

XIII.

SULPHUR.

THIS is a very remarkable elementary form of matter, and its chemical examination will afford you much curious and useful information.

Sulphur, or *brimstone*, as it is vulgarly called, is a most abundant and well-known substance, occurring in commerce in three states, viz., *native sulphur*, *roll sulphur*, and *flowers of sulphur*.

Native sulphur, so called from its occurring in a free or uncombined state, is found in large quantities in many parts of the world, and is singularly plentiful in Sicily, from whence the English market is almost exclusively supplied; it comes over in large square or oblong blocks, into which forms it has been cast after undergoing a rough purification by fusion, and the quantity thus annually imported is betweeen 16,000 and 17,000 tons.

It is the purest commercial variety of sulphur, and is therefore largely consumed in the manufacture of gunpowder, of sulphuric acid, and in some operations of bleaching.

Besides being found in the native state, sulphur occurs in combination with many metals, forming a class of compounds called *sulphurets;* those of iron and of copper are well known to almost every one, under the common names of iron and copper pyrites.

Copper pyrites, or sulphuret of copper, is a most important ore of copper; and in the mining districts of Cornwall, during the operations of reducing the metal from its ore, vast quantities of sulphur are collected in an impure state; it is purified by being melted in pots, when part of the impurities rise to the surface, and are skimmed off, small part settle to the bottom, and the purer portions are poured into cylindrical moulds of beech-wood previously soaked in water to prevent the sulphur from sticking to them: in these moulds it concretes, and when they are opened, it appears in the state of *roll sulphur*, *stick sulphur*, or *roll brimstone*, which is too well known to require any further description.

The chief, and indeed the almost exclusive, use of roll sulphur is for tipping common matches, and its consumption in this apparently trifling article of manufacture is something quite enormous: it has been calculated that not less than three tons of sulphur are thus annually consumed in London alone.

Matches are usually sold at the rate of seven pence per thousand, and the value of a year's consumption of them in England amounts to somewhere about twenty-six thousand pounds sterling.

Flowers of sulphur, or *flowers of brimstone*, is obtained by heating sulphur until it rises in vapour or sublimes into very large receivers, where it cools or condenses very rapidly into the form of a bright yellow crystalline powder. It is largely used in pharmacy, but is unfit for the manufacture of gunpowder or fireworks, in consequence of containing a little acid, which is formed during the sublimation, and this acid, which we shall consider by-and-by, is highly injurious to the other materials employed in the art of pyrotechny.

You can have no difficulty in understanding why the terms *roll sulphur* and *stick sulphur* are applied to the second variety of sulphur that I have spoken of; for it must be sufficiently evident to you that the form of the substance resembles that of a roll or cylindrical stick, but perhaps the reason of the terms *flowers of sulphur*, or *flowers of brimstone* is not quite so obvious, and therefore calls for an explanation, which is as follows.

Sublimation, or the conversion of a solid substance into vapour by heat, and the reconversion of the vapour into the solid state by cold, is a process which was invented by the earliest alchymists, and they conferred the name of *flowers* upon all such sublimed products as were light and flocculent, under the idea (a fanciful one) that they bore some analogy to the natural flowers of plants,—hence they named the light and flocculent form of sublimed sulphur *flowers of sulphur;* but this term at present is very commonly corrupted into *flour of sulphur*, perhaps on account of its state of division resembling that of flour. The vulgar term *brimstone* is a corruption of the Saxon word *brenstone*, which signifies burning-stone, a name applied to sulphur in consequence of its inflammable nature.

Having thus said a few words respecting the common varieties of sulphur, we will proceed to examine some of its properties.

It is a solid substance of a pale yellow colour, considerably heavier than water, its specific gravity varying between 1·970 and 2·080; it is very brittle, admitting of reduction to powder with the greatest facility. A curious circumstance happens, when this is done in a perfectly clean and dry Wedgwood's mortar, viz., the adhesion of the finely-powdered sulphur to its interior, so that it will not fall out if the mortar be turned upside down; you can easily try this by powdering a bit of sulphur about the size of a hazel-nut very finely. This adhesion is owing to the excitation of electricity; the sulphur by the friction becomes *negatively* electrical, and therefore is strongly attracted to the interior surface of the mortar, which is *positively* electrical, in obedience to that law of the science of electricity which teaches us that when bodies are in *opposite* electrical states they *attract* each other.

The fact of sulphur becoming electrical by friction may be proved in another way, by simply rubbing a stick of roll sulphur pretty briskly on a warm and dry flannel, and then presenting it to some little fragments of cut paper, paper ashes, or gold leaf, any of which light substances will be strongly attracted by it.

Sulphur is perfectly insoluble in water; if you put a lump of it into water, and leave it for a day or two, you will find that it has not diminished in weight nor in bulk, and as it is thus insoluble in water, I need hardly tell you that it is tasteless.

Sulphur melts with great facility upon the application of a very moderate heat: put a little bit at the bottom of a small glass tube, about half an inch in diameter, and four inches long, closed hermetically at one end, and heat it gently by the flame of a spirit-lamp; on the first application of the heat the sulphur crackles and splits (on account of the unequal expansion of its particles by heat); it then begins to melt, and soon becomes perfectly liquid, and of a bright yellowish-brown colour; but now continue the heat, and you will find (contrary to what you might expect), that, instead of remaining liquid, it will soon become thick and pasty, so that at length the tube may be inverted without any chance of the sulphur running out; it will, however, regain its fluidity as it cools. This is a very curious property of sulphur, and remains as yet unexplained.

If, when in the pasty state, you increase the heat, the sulphur will also regain its fluidity, and begin to boil rapidly, emitting a dark orange-coloured vapour, which sublimes and condenses in the upper and colder part of the tube.

The temperature at which sulphur first enters into fusion is about 216° of Fahrenheit's scale; this is only 4° above the boiling point of water: it assumes the brown pasty state between 300° and 400°; it boils and sublimes at 600°, and if pure leaves no residue.

In passing from the fluid to the solid state, sulphur always manifests a tendency to assume the crystalline form; this you will see upon examining the central part of a stick of roll sulphur, but you can easily obtain very beautiful crystals, by observing the following directions.

Take an earthen basin capable of holding about a pint, place it in a large iron ladle containing sand enough to surround the basin up to its brim, set the ladle over a slow fire, and let it heat gradually; then having broken two or three pounds of roll sulphur into bits as large as hazel-nuts, drop them, a few at a time, into the basin, and as they melt, add more, and so on by degrees until the basin is quite full of melted sulphur; then put on a thick worsted glove, and lift the basin out of the sand, and set it on the floor or upon a steady table, in order that it may cool gradually.

Watch it as it cools, and you will find small crystals beginning to form at its sides, which will presently shoot over the surface, and as soon as the whole surface is covered with them, lay hold of the basin with your gloved hand, and quickly invert it, so that the interior portion of sulphur, which is yet fluid, may run out into an earthen pan placed to receive it; hold the basin thus inverted for about half a minute, and then, upon examining its interior, you will find it completely lined with beautiful needle-shaped crystals of sulphur.

This is an example of crystallization being effected by the fusion and slow cooling of a solid substance, and the larger the quantity of sulphur that you employ, and the slower that you allow it to cool, the larger and the more perfect will the crystals be; you must be careful not to employ too much heat, or otherwise the sulphur will become pasty and intractable: no more heat is requisite than just enough to melt it.

Sulphur is highly inflammable: it takes fire at the temperature of 300° when heated in the open air, and burns with a peculiar pale blue light, emitting, at the same time, a most suffocating odour, commonly called a "sulphury smell." The tip of a common match, when applied to red-hot tinder, in the every-day operation of "striking a light," furnishes you at once with the specimen of the flame of sulphur, and the odour of its combustion.

This order is due to the formation of *sulphurous acid gas* by the union of the burning *sulphur* with the *oxygen* of the air; and it is the first compound of sulphur that we have to examine.

Sulphurous acid is produced whenever sulphur is burned in common air, or in oxygen, and also, in some instances, by acting upon certain compounds of sulphur by means of metals, as will presently appear; the experiment of the combustion of sulphur in oxygen is an exceedingly beautiful one, and may be performed after the manner directed for the combustion of phosphorus and hydrogen, Vol. II., p. 189.

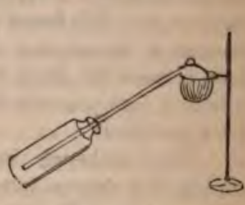
The water in the bottle absorbs the fumes of the sulphurous acid gas, and such solution will first redden and afterwards bleach litmus paper; it is in consequence of being such a powerful discharger of colour, that sulphurous acid is very frequently employed for bleaching, especially for bleaching straw or silk; the manner in which this is effected is to hang the articles in a close chamber in which a quantity of sulphur is burning: the fumes of sulphurous acid which are thus evolved exert their peculiar action upon the colouring matter of the straw or silk, and bleach it. None but native sulphur is used for this purpose, as it is found that any other variety (and roll sulphur especially,) causes dark and unsightly spots to appear on the goods; this, of course, is a great detriment to them, and is always avoided by the careful manufacturer.

Pliny says that sulphur renders woollen stuffs white and soft, and from this we may fairly conclude that the ancients were acquainted with the art of bleaching flannel somewhat after the method now practised.

A very good illustration of the bleaching power of sulphurous acid gas is furnished, when a few lighted sulphur matches are held beneath a red rose: its petals soon become perfectly blanched.

Sulphurous acid gas may be obtained in a far more pure and concentrated state by acting upon sulphuric acid by means of mercury, in the following manner.

Take a small tubulated glass retort having a long neck (perfectly dry inside), fold up a piece of white blotting-paper about the size of an octavo page into a long slip, and thrust it up the neck of the retort; into its bulb introduce through the tubulure about an ounce of mercury, and an ounce of strong sulphuric acid; insert the stopper of the tubulure, which should be slightly greased, and now place the retort on a stand as here shown, with its beak inserted into a dry bottle, whose ground stopper you have ready at hand slightly greased. Apply the flame of a spirit-lamp very gently to the bottom of the retort, so as to warm it gradually, and you will presently find an effervescence take place, which is due to the evolution of sulphurous acid, and it being a very *heavy* gas, will pass down the neck by the retort into the bottle, and expelling the common air, will soon completely fill it; you can pretty well judge when the bottle is full by the escape of the gas from its mouth, and also by its action upon a bit of litmus paper, or the petals of a red rose, held near it, and when the bottle is full, lift up the neck of the retort, and insert the stopper quickly. Put another bottle in its place, and fill it as before, and thus you may go on until you find the materials in the retort becoming white and solid, and then it is prudent to stop the operation. You must be particularly cautious to avoid inhaling any of the gas, for it is highly deleterious, and therefore it is better to conduct the process out-of-doors, or in a good draught, as formerly directed, when speaking of chlorine.



Sulphurous acid is a perfectly invisible gaseous body, and considerably more than twice as heavy as air, its specific gravity being 2·22, and therefore you can easily pour it from one vessel to another, just as you did with chlorine (Vol. II., p. 295,) and if you put a lighted paper into it, the flame is instantly extinguished; it is also instantly fatal to animal life. A mouse or bird put into its atmosphere is suffocated directly, but there is no occasion whatever for you to make such a cruel experiment.

Sulphurous acid gas is very soluble in water; this you have already had evidence of in the experiment of burning sulphur in oxygen, but you can make a solution of the gas, by pouring a little water into one of the bottles of it, and then putting in the stopper with a bit of string or paper between its ground-part to allow the entrance of air, whilst you agitate the bottle to promote the absorption of the gas. If you neglect this precaution, the stopper will become fixed by atmospheric pressure, and you will never be able to remove it afterwards (Vol. II., p. 292). The aqueous solution thus obtained is transparent and colourless, smelling strongly of the gas, and acting upon vegetable colours as already described.

Water dissolves more than thirty times its bulk of the gas at common temperatures and pressures, but when heated, the gas escapes; this you can *prove* by heating a portion of the solution in a small cup held *over a spirit-lamp*, and you will find that as soon as it boils, the gas is abundantly expelled, and at length no traces of it are discoverable in the water which remains; of course you must make this experiment out-of-doors, or beneath a chimney, so that you may not be annoyed by the suffocating odour.

If, on the other hand, you cool the aqueous solution, the gas shows no tendency to escape: take a small phial containing a portion of it, and plunge it into a mixture of equal parts of powdered ice or snow and common salt; this forms what is called a "freezing mixture," and will very soon cause the solution of sulphurous acid to freeze. When this happens, remove the phial, let its contents thaw, and then heat the solution as before, and you will find that the gas is expelled, just as it was in the last experiment.

Now, although in common parlance we call this compound of sulphur and oxygen sulphurous acid *gas*, we mean by the term that it is only gaseous at all ordinary temperatures and pressures; it is in fact a *vapour*, and passes into the liquid state when exposed to the joint action of cold and pressure.

The equivalent or combining proportion of sulphur is 16, and it combines with 2 proportionals of oxygen = 16 to constitute 1 proportional = 32 of sulphurous acid gas, so that you see it is constituted of equal weights of sulphur and oxygen.

It is called an acid gas, because it feebly reddens vegetable blue colours previous to destroying them, and combines with certain bases, such as ammonia, potassa, soda, &c., forming a class of salts which are called *sulphites;* these, however, are of very little importance.

We have now to examine the second compound of sulphur and oxygen, viz., the *sulphuric acid*, or *oil of vitriol*. You can easily purchase a pound or two of it of the operative chemists, which quantity will be quite sufficient for all the experiments I am about to describe.

The term *sulphuric acid* of course implies that it is a compound of sulphur, with more oxygen than the *sulphurous acid*, agreeably to the slight sketch of chemical nomenclature given in a former paper (Vol. I., p. 298), and chemists almost invariably describe it by this term; it is, however, very commonly known in commerce and the arts as *oil of vitriol*, a name given to it in consequence of its preparation many years ago by the distillation of *green vitriol*, or sulphate of iron; and thus prepared appearing as a dense smooth-pouring liquid, it was called the *oil* of vitriol. It was also called *oil* of sulphur, when formed by the combustion of sulphur under certain circumstances.

When first manufactured for sale, the price of sulphuric acid was very high (as much as thirteen shillings per pound), in consequence of the difficulty and time required to produce it in any quantity; indeed, in order to procure the small quantity of five ounces, it was necessary to labour incessantly for twenty-four hours, and this result, small as it may appear, was regarded as extremely good and copious.

As, however, chemistry advanced, so was the process improved and expedited, and we are indebted to the celebrated Dr. Ward for the process which is now followed. He burned the sulphur mixed with a small proportion of nitre, and by making his experiments upon a large scale, he obtained very copious results, and was enabled to sell sulphuric acid at the rate of half-a-crown per pound. The name which he conferred upon it was that of *oil of sulphur per campanam*, alluding to the *bell-glass* into which the fumes of the burning sulphur were collected and condensed.

The experiment is very easily made, and will serve as an illustration of the production of the acid in a diluted state. Mix a portion of powdered sulphur with one-eighth part by weight of powdered nitre, and put about a tea-spoonful of this mixture on the bottom of a tea-cup turned upside down; set this in the centre of a soup-plate, having its bottom covered with water, then drop a red-hot coal on the mixture; it will take fire, and you must now quickly invert over it a large bell-glass so as to stand in the water of the plate; the combustion will now go on; the fumes which are produced are absorbed by the water, and when all is over, if you dip a bit of litmus paper into the water you will find the test reddened by the sulphuric acid thus produced. The theory of the operation will be explained hereafter. This method was followed for a very long time, but in the year 1746 Dr. Roebuck began manufacturing sulphuric acid by burning the mixture of sulphur and nitre in large leaden chambers instead of beneath glass bells, and since his time many manufactories of the acid have been established upon this plan.

The following is a very brief outline of the mode at present adopted for the manufacture of this highly important acid:—The mixture of sulphur and nitre is burned in extensive chambers wholly lined with lead, and covered at the bottom with a thin sheet of water; by the agency of the nitre the sulphur becomes more powerfully acidified than when burnt alone, and the fumes of the combustion are absorbed by the water. Repeated charges of the mixture are thus burned, and the operation is conducted day and night without intermission, until the water is deemed to be sufficiently impregnated with the acid. It is then drawn off, and evaporated in leaden kettles until it acquires a considerable degree of density (because sulphuric acid is not volatile by heat like the sulphurous acid); it is then transferred to retorts, and the concentration still further effected by driving off more water. Some manufacturers do not evaporate in lead, but transfer the acid water at once into platinum retorts, which, although greatly expensive, and costing from three, to four hundred pounds each, are found to be more economical in the long run than retorts of more brittle or perishable materials, such as the glass retorts, which were invariably employed before the introduction of this invaluable metal.

This process of concentrating the acid, whether conducted in glass retorts or platinum stills, is called *retorting;* and during it, all volatile impurities are expelled, and the sulphuric acid remains in a high degree of purity and strength. It is next transferred to what are called *carboys*, viz., large globular bottles of green glass set in baskets, and packed round with straw; an earthen stopper is fitted to the mouth of each; some clay is placed over this, and the whole tied over with coarse canvass. In this state sulphuric acid comes into the market, and the average weight of each carboy is between 100 and 120 pounds.

The quantity of sulphuric acid thus annually manufactured and consumed falls very little short of fifty thousand tons, and it is sold at the singularly low rate of ten shillings per cwt.

You will naturally enough inquire, what can be the demand for this enormous quantity of sulphuric acid? Why, in the first place, the great consumers of it are the manufacturers of soda from common salt, which it decomposes, forming muriatic acid and sulphate of soda; and this sulphate is converted into soda by calcination with chalk and charcoal. Then, many other chemical products depend upon the agency of sulphuric acid. It is employed to decompose nitre to produce nitric acid; the manufacturers of citric and tartaric acids employ it to separate them from their combinations; and the manufacturer of sulphate of magnesia consumes it by tons.

It is in constant demand with dyers, calico-printers, and bleachers, for the preparation or destruction of vegetable or animal colouring matters. It is used by the workers in metals, more especially by the refiners of gold and silver. The tallow-chandlers employ it for purifying oil and tallow; the manufacturer of soda water for expelling carbonic acid from chalk. A great deal is used in pharmacy; a larger quantity in the experimental laboratory; and no inconsiderable quantity is consumed in cleaning copper vessels, such as saucepans, kettles, and scuttles, and also in the manufacture of blacking.

We will now proceed to examine some of the properties of this abundant and important acid.

As it usually occurs, sulphuric acid is a dense, limpid, colourless, and inodorous liquid, having a specific gravity $= 1{\cdot}84$; it is intensely acrid and caustic, so that you must be exceedingly cautious how you handle it, taking care that none of it drops upon the hands or clothes. Even when largely diluted with water, it manifests its acid property in a high degree; if you fill a tumbler full of water, and add to it only a single drop of the acid, which is best done by dipping the end of a glass rod or a bit of clean tobacco-pipe into it, and then stirring it round in the water, you will find that even in this highly diluted state it will redden litmus paper.

Sulphuric acid has a very powerful attraction for water, absorbing it from the air with avidity, and at the same time diminishing in strength, so that you must keep it in a bottle closed with a well ground stopper, or it will soon become weakened. If you pour a little into a wine-glass, and mark the level at which it stands, and then leave it exposed for some days to the air, you will find that the acid absorbs aqueous vapour, and increases in bulk, so that the level of the liquid stands considerably higher than the mark on the glass.

It has been ascertained that the strongest acid, viz., specific gravity $= 1{\cdot}84$, will absorb considerably more than eight times its weight of water if exposed for a month to the action of air saturated with aqueous vapour.

In pouring the acid from the bottle in any of your experiments, if a drop of it remains about the neck, it soon begins to absorb water, and dribbles down the sides of the bottle on to the table or shelf upon which it stands, so that in the course of a short time you find the bottle standing in a little pool of dilute acid; this destroys the neat appearance of tables, shelves, or partitions in a case of chemicals, and therefore it is best to place the bottle of acid on a shallow leaden tray, upon which metal it exerts but little action.

Upon *suddenly* mixing sulphuric acid with water, its intense attraction for that fluid is manifested by the evolution of a degree of heat sufficient to boil some liquids, and to cause the combustion of some solids; two parts of acid suddenly mixed with one part of water cause an elevation of temperature very considerably above the boiling point of water; considerable caution is requisite in making the experiment. Many a fine glass retort or bottle has been broken by the juvenile student in making this mixture with inattention to the heat evolved. You can safely and successfully perform the experiment as follows:—Take a six-ounce gallipot and measure into it two ounces of sulphuric acid, then set it to stand in a soup-plate or basin (and the use of doing this is merely to catch the acid should the gallipot break by the heat when the water is added); pour a little ether into a test-tube similar to that already spoken of, and place this tube in the acid, then quickly add an ounce of water to the acid, and the moment that you do this you will find a great deal of heat is evolved in consequence of the mutual attraction of the two substances for each other, and the ether in the tube begins to boil furiously. You may kindle its vapour at the mouth of the tube, and it will burn with a fine bright flame.

If you place a bit of phosphorus about the size of a peppercorn in a tea-spoon, and place it so that the bowl touches the acid, you will very likely find that the phosphorus takes fire and burns brilliantly.

Remember that you ought never to attempt this sudden dilution of the acid in glass vessels, for they will almost invariably crack with the heat. I have known the bottom of a glass vessel, holding a gallon of water, cracked by merely pouring in two ounces of strong acid, and for this reason: the acid being so dense or heavy, fell through the water to the bottom of the glass, and there, suddenly combining with the water in immediate contact with it, produced sufficient heat to cause the glass to crack.

Sulphuric acid boils at 620°, and so great is its attraction for water, that it even absorbs it at this temperature; the manufacturer, therefore, finds that he cannot concentrate it so well in open as in closed vessels, or rather, vessels having comparatively small openings, as the platinum retorts or stills already mentioned.

As a chemical agent, this acid is intensely active; it displaces the greater number of other acids from their combinations; thus, you will remember that we employed it to act upon muriate of ammonia to evolve muriatic acid, and upon nitrate of potassa, to evolve nitric acid (see Vol. III., p. 360), and acids which have a weaker affinity for their bases are yet more readily expelled from combination with them, by the acid in a diluted state.

Thus, chalk is a *carbonate of lime*, that is, a compound of *carbonic acid* and lime (Vol. I., p. 303); and if you drop a fragment of chalk into some of the acid which you have just diluted in the gallipot, you will find a violent effervescence take place, which is due to the expulsion *of carbonic acid gas* from the lime, the sulphuric acid taking its place, and forming *sulphate of lime*, which remains as an insoluble white substance.

This is the way in which the manufacturer of soda water obtains carbonic acid gas, as I shall describe to you in the next essay.

Sulphuric acid exerts an intense action upon vegetable and animal matters; it chars and decomposes them, probably on account of rapidly abstracting the water which they contain as one of their elements.

A few bits of wood, cork, or straw, dropped into sulphuric acid, will instantly begin to char, blacken, and discolour it; even a single straw dropped into a whole carboy of acid is sufficient to render it perceptibly brown.

On a former occasion I told you that *sugar* is a compound of *water* and *charcoal;* and accordingly, if you take a little finely-powdered lump sugar, and drop it into sulphuric acid, the acid, in seizing the water, will liberate the charcoal in its black form.

Or you may render the experiment still more striking, if you dissolve a large quantity of loaf sugar in a very small quantity of water, so as to form a strong syrup: by doing this, you will entice the sulphuric acid to snatch away the water very rapidly, and the combined and really elementary water of the sugar will also follow it, and charcoal will remain behind.

This you must perform as follows:—Take a gallipot of the same size that you employed just now for the dilution of the acid, and arrange it in a basin or plate in a similar way; pour about an ounce of strong syrup into it, and add to this two ounces of strong sulphuric acid; at first there appears to be little attraction between the two bodies, but now stir them together with a long glass rod; they will presently blacken, grow intensely hot, and ultimately a vast quantity of charcoal will be evolved in the black and solid form.

This is a very beautiful, and almost magical experiment, and it is an excellent illustration of the total change of form which bodies sustain when made to act chemically upon each other.

If the acid is very strong, the action often takes place with such vehemence that portions of the materials are spurted out of the vessel; therefore you must guard against this, not only by putting the gallipot in a basin or plate, but by placing this under the chimney, and stirring the materials with the glass rod held at arm's length; never hold your face over any apparatus in which an experiment is performing.

The generality of vegetable blue colours are reddened by acids, and are therefore employed as tests of their presence; but it is a curious fact, that *indigo* dissolves in sulphuric acid without undergoing any change of colour.

You may readily make this solution, by reducing a small lump of indigo to a fine powder, putting this into a florence flask, or even a large glass test tube, along with sufficient sulphuric acid to cover the powder; upon applying a gentle heat, an intensely blue solution of indigo is obtained, which is commonly known as *liquid* or *Saxon blue;* chemists frequently call it *sulphate of indigo*.

It is frequently used in some of the processes of dyeing, and also for staining willow chips of a fine blue colour for ornamental basket-work.

It has the property of colouring a very large quantity of water intensely blue: a single drop of it will colour two or three quarts of water; and when thus diluted, it forms a very useful liquid for exhibiting the effect of chlorine in bleaching, as you have formerly seen (Vol. II., p. 293).

Sulphuric acid is productive of more injury to the clothes of experimenters than almost any other: it corrodes cloths, aprons, &c., and causes them to drop into holes when hung near the fire to dry.

You may form some notion of this destructive property, by soaking a piece of white calico in the diluted acid; no action will be perceptible so long as it remains wet, but now hold it before the fire, and as soon as the water begins to evaporate, the acid becomes concentrated, and chars the cloth just as a hot iron would do.

You often hear of evil-minded persons throwing sulphuric acid (or vitriol, as it is vulgarly called,) over clothes, in order to destroy them, or to cause injury to the wearer; such nefarious trick is regarded by our law as an act of felony, and a severe and just punishment can be awarded to those guilty of it.

Being a substance of such corrosive nature, I need hardly tell you that it is eminently poisonous; and there are many instances upon record, of persons, especially children, who have accidentally swallowed it in mistake for capillaire, or some such syrupy matter, to which it certainly bears considerable resemblance, in its smooth and noiseless pouring from one vessel to another.

In a case of poisoning by sulphuric acid, the plan adopted by the medical practitioner is to cause the patient to swallow copious draughts of water mixed with *plain magnesia* (carbonate of magnesia), or, when this is not at hand, he substitutes *whiting* (carbonate of lime); either of these substances will combine with the sulphuric acid, and neutralize it, and in this way, if too much time has not elapsed before these antidotes are administered, they generally prevent any fatal result from ensuing.

I must now say a few words regarding the composition of sulphuric acid; it is found to consist of 1 proportional of sulphur, 16 + 3 proportionals of oxygen 24, so that its equivalent number is 40: and in this proportion it combines with bases to form a very numerous and important class of salts, called *sulphates;* but as it occurs in commerce in the liquid state, and having a specific gravity of 1·84, the 40 of dry or anhydrous acid are combined with 9 parts, or 1 equivalent of water, so that the equivalent number of the acid which we have been experimenting with is 49: but whenever this liquid acid is presented to a base, the real acid combines with it, and the water is thrown off.

Under certain circumstances, however, sulphuric acid can be obtained in an insulated state, perfectly dry, or anhydrous, and it then appears as a white crystalline solid.

Such being the composition of sulphuric acid, you see the reason why we employed it for the production of sulphurous acid gas: by heating it with mercury, and thus causing the metal to abstract one proportional of oxygen. It is also similarly decomposed by several other metals, which, becoming oxidized at the expense of a portion of its oxygen, evolve sulphurous acid gas.

When metals, such as iron or zinc, are dissolved in *diluted* sulphuric acid, you will remember that the *water* only undergoes decomposition; its oxygen is transferred to the metal, forming an *oxide*, which the *sulphuric acid* combines with to form a *sulphate*, and the *hydrogen* of the water is evolved in a gaseous state (see Vol. III., p. 17).

The presence of sulphuric acid, either in its free state or in that of any soluble combination, may be judged of by the action of a solution of *nitrate of baryta*, which instantly detects it, by precipitating an insoluble *sulphate of baryta*. Of this you can easily convince yourself, by adding the solution of nitrate of baryta to some diluted sulphuric acid, and also to diluted solutions of the sulphates of magnesia, zinc, and copper.

You have now before you a few of the leading properties of this important acid, and therefore I will direct your attention to the theory of its production in the process of burning sulphur with nitre.

Sulphur, when burned alone, either in air or in oxygen, forms sulphurous acid, but when burned with nitre, how comes it that an additional dose or proportional of oxygen is attracted, and sulphuric acid formed?

Some chemists imagined that the nitre (nitrate of potassa) gave up its oxygen directly to the sulphur; but then, so very small a quantity of nitre, only one-eighth part of the weight of the sulphur, was found to be sufficient, and therefore contradicted this notion.

The production of sulphuric acid in this way remained for a long time unexplained, but we now know the true solution of the matter, which is very simple, and very beautiful, as I will endeavour to show.

When the mixture of sulphur and nitre is burned, sulphurous acid is produced by the union of the sulphur with the oxygen of the air, at the same time that the nitric acid of the nitre is decomposed, and the vapour of nitrous acid evolved; the sulphurous acid gas and the nitrous acid gas form a white crystalline compound, and this, meeting with the water upon the floor of the chamber, is instantly decomposed: the nitrous acid passes into the state of nitric oxide, by transferring one proportional of its oxygen to the sulphurous acid, and therefore produces sulphuric acid, whilst the nitric oxide absorbs oxygen from the air of the chamber, passes back again into nitrous acid, and is ready to transfer oxygen again to another portion of sulphurous acid, and convert it into sulphuric acid.

Such is the theory of the process to which we are indebted for the enormous supply of sulphuric acid already adverted to, and although some processes have been invented for its production without the agency of nitre, yet I believe that they are by no means generally followed.

Although sent into the market so very abundantly, and at such a cheap rate, sulphuric acid is generally in a state of great purity; its specific gravity should not exceed 1·85, and this you can readily ascertain as follows:—

Take the *tare* of a four-ounce phial, then place a thousand-grain weight in the scale with the tare, and cautiously pour distilled water into the phial until an equilibrium is effected, and then make a mark with a fine file upon the phial at the level of the water.

Now empty the phial, and dry it out perfectly; if it has a wide mouth this is easily done with a little bit of tow or lint wrapped round the end of a wire or thin whalebone, or if the neck be narrow, by washing it out with a little strong spirits of wine, then heating it before the fire and blowing into it with a pair of bellows, having a long tube attached to the nozzle (Vol. III., p. 139). When the phial is thus dried and cool, fill it very carefully up to the file-mark with your sulphuric acid, and then place it in the scale; you will find that it greatly exceeds the thousand-grain weight, and that you must add eight hundred and forty grains, or thereabouts, in order to restore the equilibrium of the balance.

This proves that *equal bulks* of *water* and of *sulphuric acid* have very *different weights;* and if you call the weight of water 1·000, that of the sulphuric acid will be 1·840.

Perhaps you will not obtain the exact specific gravity of 1·840, but it will not be far short of it if the acid is good.

It has been already stated that sulphuric acid greedily absorbs water from the air, and at the same time diminishes in strength, or, what amounts to the same thing, in specific gravity, by so doing, and this you can strikingly prove by leaving the phial in the balance for some days, or weeks, exposed to the air; you will find that the level of the acid gradually rises above the file-mark, increasing in bulk, in consequence of slowly absorbing water; and if the process be allowed to go on to a very considerable length, the phial will ultimately become quite filled with the acid thus diluted and weakened.

That it is weakened you may prove by pouring out the liquid which stands above the file-mark, and then weighing what remains. If the acid had not decreased in strength, the 840 grains should now exactly balance it as before; but you will find that a very much less weight is sufficient to effect an equilibrium; and whatever this weight happens to be, if you add it to 1000, it gives you the specific gravity of the diluted acid.

The most common impurity of sulphuric acid is *sulphate of lead*, derived of course from the leaden chamber in which the acid is formed; now this salt of lead, although soluble in the strong, is insoluble in the dilute acid; and accordingly, if you copiously dilute the acid with water, if the sulphate is present it will be precipitated in the form of a white cloud.

The presence of other insoluble impurities may be judged of by evaporating a portion of the acid to dryness, in a bit of a broken florence flask, held with a pair of tongs over a spirit-lamp placed under a chimney so as to carry off the fumes; if pure, the acid should entirely disappear and leave no residue.

Sulphuric acid is occasionally found as a native product in the lakes of some volcanic districts.

During this inquiry I have had frequent occasion to advert to the existence of *sulphates;* they are an extremely numerous and important class of salts, but their individual histories would lead us into a field of discussion far too extensive for the present occasion; and indeed, until the nature of each particular base with which the acid combines has been brought before you, any details regarding their combinations with sulphuric acid would necessarily be incomplete; these observations, however, do not apply to the *sulphate of ammonia*, because the nature of that alkaline base has been already discussed (Vol. IV., p. 28).

The sulphate of ammonia may be obtained by neutralizing dilute sulphuric acid with *liquor ammoniæ*, or carbonate of ammonia; the solution thus formed, if cautiously evaporated and set aside to crystallize, yields six-sided prismatic crystals, very soluble, having a bitter pungent taste, and containing water of crystallization.

The composition of this salt is here subjoined. Sulphuric acid, 40; ammonia, 17; water, 18; giving you the equivalent 75 as that of the sulphate of ammonia; or, in other words, the salt consists of 1 proportional of acid, 1 of alkali, and 2 proportionals of water.

This salt is formed in many operations of manufacturing chemistry, and is highly important as a source of other compounds of ammonia; for example, when sublimed with common salt, it is decomposed, and produces *muriate of ammonia*, or, if similarly treated with carbonate of lime, *carbonate of ammonia* results.

There are two other compounds of sulphur and oxygen, viz., the *hyposulphurous* and *hyposulphuric acids;* the former consisting of sulphur + 8 oxygen, the latter of 16 sulphur + 20 oxygen; but they are but very little known, and require complicated processes for their production.

Sulphur combines with chlorine, iodine, and bromine, producing a chloride, iodide and bromide of sulphur; but these compounds need not detain us, as they have very little popular interest. We will therefore pass on to the compound of sulphur with hydrogen, viz., *sulphuretted hydrogen gas.*

In order to obtain this singular substance, you must first of all form a *sulphuret of iron;* and this is effected by putting about four ounces of iron filings, or turnings, into a crucible, which is then to be heated red hot in the fire.

If you now throw into the crucible a few bits of sulphur, an energetic action takes place, the iron glows with a brilliant red light, and combines rapidly with the sulphur; keep on adding a few bits at a time, and you will soon find that the whole of the iron melts, and there remains in the crucible a fluid sulphuret of iron. You can judge when enough sulphur has been added, by the cessation of the red light, or ignition, and the simple burning of a bit of sulphur when thrown in.

The crucible is now to be taken out of the fire and allowed to cool, and then, if you break it with a hammer, you obtain a lump of *sulphuret of iron*, which is a blackish brittle compound, consisting of 1 proportional of sulphur 16 + 1 proportional of iron 28.

The experiment is a good illustration of the formation of a metallic *sulphuret*, which term you will remember is applied to the union of sulphur with an *element*, and hence its distinction from *sulphite* or *sulphate*, which terms imply the union of *compounds* of sulphur and oxygen with *bases* or *compounds of elements.*

Now, if you put a bit of *iron* into diluted sulphuric acid, you observe an evolution of *hydrogen* gas; but supposing that you put a bit of *sulphuret of iron* into the acid, what will happen? Why, *hydrogen* will be generated, but then in its nascent state meeting with *sulphur*, it will unite with it, and the gaseous product will be a *sulphuret of hydrogen*, or, as it is more commonly called, *sulphuretted hydrogen*.

Well, then, reduce some of the sulphuret of iron to a coarse powder, put it into a gas bottle, and act upon it with diluted sulphuric acid exactly as directed for hydrogen, (Vol. II., p. 363,) only that the bent tube of the gas bottle had better be of glass. (You had better make the experiment out-of-doors, because the gas has the most abominable odour, perhaps, of all the products of the laboratory.) The pneumatic trough is to contain cold water, and the gas is to be collected in stoppered bottles; three or four pints will be sufficient for our experiments.

Sulphuretted hydrogen is transparent, invisible, and permanently gaseous at all common temperatures and pressures; but it assumes the state of a colourless liquid when subjected to a low temperature and high pressure. I furnish you with no directions regarding the mode of experimenting to effect the liquefaction of this or other gases, because the operation is both difficult and dangerous.

The abominable odour of sulphuretted hydrogen is a property with which you will become acquainted during the operation of collecting it in the pneumatic trough; it resembles that of rotten eggs, and if even a very little escapes into a large room, the whole of the air is soon disagreeably contaminated by it.

It is highly deleterious to animal life, even when thus largely diluted with common air, and therefore you must be extremely cautious in your operations that you do not inhale it; chemists have found that in air containing only $\frac{1}{1500}$th part of sulphuretted hydrogen, a bird dies immediately.

It is an inflammable gas, and burns with a peculiar lambent blue flame; set a bottle of it on the table, remove the stopper quickly, plunge in a lighted taper, and you will find the gas take fire, whilst the taper is extinguished, so that although itself combustible, the gas will not support combustion. Whilst it burns, you will observe that a considerable portion of sulphur is deposited in the solid state; some is burned, and produces sulphurous acid, and the hydrogen, at the same time, forms water.

Now, although you have collected this gas over water, it cannot be retained any length of time over that fluid, because it is soluble in water to a very considerable extent, and hence the necessity of preserving it in stoppered bottles as you did with chlorine; you may easily make its aqueous solution by pouring a little water into a bottle of the gas, and then agitating, with the precautions spoken of already, *i. e.*, putting a bit of string or paper between the ground parts of the stopper.

This aqueous solution smells strongly of the gas, and it is a most valuable test of the presence of many metals, but more especially of *lead*.

Drop a little atom of any salt of lead, the carbonate or the acetate, into a solution of sulphuretted hydrogen, and you will find it instantly discoloured and blackened,—indeed, if the inside of your pneumatic trough happens to be painted white with white lead (carbonate of lead), it will turn perfectly black whilst you are collecting the gas, so also will any white paint in the vicinity of the gas; but when giving you the history of the metal lead, I shall go into this matter much more in detail, and therefore say no more at present, except to warn you not to allow the gas to escape in any delicately-painted room, or near oil-paintings, for it will do irreparable damage:—confine your experiments to your own laboratory.

Sulphuretted hydrogen gas consists of 1 proportional of sulphur 16 + 1 proportional of hydrogen 1: its equivalent number therefore is 17.

It is very readily decomposed by many agents; if you transfer a little of it into a tall jar standing over the water in the pneumatic trough, say till the jar is about half full, and then very gradually let up some bubbles of chlorine, you will find that as they break into the sulphuretted hydrogen that it is decomposed, as is evident by a cloud of sulphur being deposited; the hydrogen quitting the sulphur, and combining with the chlorine to form muriatic acid, which dissolves in the water.

So also if you pour a drop or two of nitric acid into one of the bottles of it, you effect its decomposition; sulphur is deposited, and 1 proportional of the oxygen of the nitric acid takes 1 proportional of hydrogen to form water, and leaves nitrous acid.

Sulphuretted hydrogen is abundantly produced during the decomposition of organic matters, and much of the fœtid odour which they emit when decaying, is referrible to its evolution. I have formerly mentioned chlorine as a powerful disinfecting agent: and probably the manner in which it acts upon contagious or infectious matter is by decomposing sulphuretted hydrogen, or some of its compounds.

Sulphuretted hydrogen combines with ammonia, and produces a compound called *hydrosulphuret of ammonia*, which is sometimes used as a test of the presence of metals, of which I shall speak at a future period of our course.

Chemists have hitherto in vain endeavoured to cause sulphur and nitrogen to combine; and although the two elements have been presented to each other under an almost infinite variety of circumstances, still they have not manifested the slightest attraction for each other; so that a *sulphuret of nitrogen* remains yet to be discovered.

In concluding the history of sulphur, I must remind you that it is an element, and that, unlike the alchymists, modern chemists only apply the term sulphur to this particular substance: the alchymists used the term sulphur to denote every combustible with which they were acquainted; accordingly, in their curious writings we find mention of the "sulphur of metals, sulphur of animals, sulphur of vegetables," and so forth, meaning the inflammable matters of such bodies: indeed, they imagined that all the metals consisted of *sulphur*, *mercury*, and *salt*, and that metals might be changed or transmuted, the one into the other, merely by altering the proportions of these three supposed elements; and hence originated all the fruitless labour and toil of alchymy, which, however, laid the foundation of the present science of chemistry.

MISCELLANEA.

Vegetable Origin of the Diamond.

One of the most striking physical investigations that have occurred this season, is that of Sir D. Brewster, by which he has further shown the probable vegetable basis of the diamond. He had previously remarked several peculiarities of structure in this gem, which inclined him to assign it an organic origin. Thus, for example, having detected a bubble of air in a diamond, Sir David transmitted through it a pencil of polarized light, and perceived round the bubble four luminous sectors, separated by the black cross. Now this could only be accounted for by assigning a variable density from the centre to the exterior, greatest against the bubble of air, which must have exerted a degree of compression on the matter in contact with it. On other occasions, Sir D. Brewster had remarked in certain diamonds interposed carbonized parts. At the recent Liverpool meeting, this philosopher communicated what he conceived to be a novel phenomenon; but it has been remarked in France in the diamond lenses prepared by M. Oberhauser: namely, an infinity of very fine parallel lines, which are perceived in the diamond in a certain direction, and which are very prejudicial to its employment in the construction of lenses. These lines had been regarded in France as fibres, or as fine channels; Sir D. Brewster considers them as separating so many layers of variable densities; he counted many hundreds of them in less than the one-thirtieth of an inch, and to them he attributes the duplication of the images, which were formerly supposed to be due to an ordinary effect of double refraction. He is consequently led to imagine that if diamond lenses were worked parallel to the direction of these layers, or, so that their axis was exactly perpendicular, they would not be influenced by the presence of these lines; the lens would act precisely as if the diamond were perfectly homogeneous.

Sir David states that he has not observed this structure resulting from an assemblage of fine laminæ of varying densities in any other mineral, not even in apophyllite or chabasite*, which present different degrees of extraordinary refraction in different points of the crystal, depending on a secondary law of structure. Sir David, therefore, thinks this special structure in the diamond to be a new indication of its vegetable origin, and that it was formed by the successive deposition of layers submitted to different pressures.

New Experiments on Metallochromy†.

M. **Böttiger** has obtained some remarkable effects in metallic coloration, by plunging a plate of platina, held in contact with a zinc stem, in a solution of ammoniacal chloride of copper; the platina being consequently maintained in an electro-negative state. The solution of the copper was obtained by agitating fine copper-filings in a saturated solution of sal-ammoniac. This solution of copper, which is colourless as long as it is kept in a well-stopped bottle, becomes blue by exposure to the air. If a piece of polished platina be plunged into it no effect is produced, but if the platina be touched by a piece of zinc, a thin red pellicle of copper is immediately deposited on the surface, which immediately disappears if the contact with the zinc was momentary; but if this contact is permanent, beautiful shades of yellow, green, red, brown, and black, soon appear on the platina. These colours may be fixed by withdrawing the platina and leaving it to dry in the air.

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* Apophyllite is a hydrated silicate of lime and potassa, composed of one atom of ter-silicate of potassa, three atoms of ter-silicate of lime, and sixteen of water. Chabasite is 1 bi-silicate of lime + 3 bi-silicate of alumina + 4 water, or it is a hydrated silicate of lime and alumina.

† This term was adopted by Professor Nobili, who first published some highly interesting observations on the subject. See *Scientific Memoirs*, p. 1. for a translation of *his paper.*

Iron Steam-Boat.

A STEAM-BOAT, destined to navigate the Rhone, has recently been built in England, which is the largest yet made of iron. It is named the *Sirius*; it is 164 feet long in the keel, and 176 feet on the deck; the iron plates of which it is formed are seven feet long, fourteen inches broad, and three lines thick. Though narrow on the beam, the *build* is elegant; it is to carry two engines of thirty-five horse power, and when loaded with these and its equipments, it will only draw two feet of water. The *Sirius* is divided transversely into four compartments, by three water-tight partitions, so that if an accident were to happen in one of these, the vessel would nevertheless float.—(*Echo du Monde Savant*, 18th Oct.)

Temperatures.

THE following interesting and useful tables are taken from the first part of Mr. Graham's *Elements of Chemistry*, just published by Baillière. We shall take an opportunity of recurring to this publication in our next.

RANGE OF TEMPERATURE.

−135°	Fahr.	Greatest artificial cold. Thilorier. (Obtained by freezing liquid carbonic acid.)
−121	,,	Solid compound of alcohol and carbonic acid melts.
−91	,,	Greatest artificial cold measured by Walker.
−58	,,	Temperature of planetary space. Fourier.
−60	,,	Greatest natural cold observed by Ross.
−55	,,	Greatest natural cold observed by Parry.
−47	,,	Sulphuric ether congeals.
−39	,,	Melting point of solid mercury.
−7	,,	A mixture of equal parts of alcohol and water freezes.
+7	,,	A mixture of one part of alcohol and three parts of water freezes.
+20	,,	Strong wine freezes.
+32	,,	Ice melts.
+50	,,	Medium temperature of the surface of the globe.
+52	,,	Mean temperature of England.
+98	,,	Heat of the human blood.
+150	,,	Wood-spirit boils.
+174	,,	Alcohol boils.
+212	,,	Water boils.
+442	,,	Tin melts.
+594	,,	Lead melts.
+662	,,	Mercury boils.
+980	,,	Red heat. Daniell.
+1141	,,	Heat of a common fire. Do.
+1869	,,	Brass melts. Do.
+2233	,,	Silver melts. Do.
+3479	,,	Iron melts. Do.

SPECIFIC HEAT.

	Specific Heat.		Specific Heat.
Water	1000	Zinc	93
Sulphur	188	Silver	56
Glass	117	Mercury	33
Iron	110	Platinum	31
Copper	95	Lead	29

Protococcus salinus

M. DUNAL de Montpellier, has proved, that the red colour of the salt-marshes of the Mediterranean coasts is of vegetable origin, and is not produced by the *Artemia salina*, a small crustacean. In fact, the colour is deepest in those ponds where but few Artemias are found; and this animal is not more coloured than the *Daphniæ*, or *water-fleas*, (Order, *Branchiopoda*—Class, *Crustacea*,) so common in our marshes, and to which the colour of stagnant waters has been also erroneously attributed.

M. Dunal having examined the red water of the salt-marshes with much attention, found in them an immense quantity of spherical, transparent, coloured globules, which he considers as an elementary vegetable, analogous to those which colour the red snow of the arctic regions and certain marbles. M. Dunal has consequently named it *Protococcus salinus*, to distinguish it from the *P. kermesinus* recently observed on marble.

Other waters presented a somewhat different shade of colour, and M. Dunal, on examination, detected a vegetable rather more complex in its structure, the *Hæmatococcus salinus*, of an orange red, containing in its elliptical or spherical cells minuter globules. He is inclined to think, that this may be the Protococcus in a more advanced state. However this may be, it is certain that the rosy tint and violet odour, which were attributed to the Artemia, are produced by one or other of these vegetables being inclosed in the crystals of salt, which are deposited in masses on the margins of the ponds.

Present state of Organic Chemistry.

"It can be easily conceived, that by means of a few laws of combination, we may not only produce all the compounds known in the inorganic kingdom, from the fifty-four elements now recognised, but also a great number of others analogous to them.

"But how can we apply such notions to organic chemistry? There we meet with as many, and as diversified, species as in mineral chemistry; and yet there, instead of fifty-four elements, three, or at most four, are all that are detected in the greatest number of known compounds. In a word, how can we explain by aid of the laws of inorganic chemistry, and how class the principles so various which are obtained from organized bodies, and which are all formed solely from carbon, hydrogen, and oxygen, with the occasional superaddition of azote?"

This was a splendid problem in natural philosophy, calculated to excite the emulation of chemists to solve; for, from the solution, science might expect great additions to her domain; the mysteries of vegetation and animal life would be unfolded to our view; we should possess the key to all those abrupt and singular modifications of matter which take place in animals or plants; and, what is more, we might imitate them in our laboratories.

We fear not to assert, and that with due consideration, that this splendid problem is now solved; it only remains to develop all the consequences which its solution brings out. And, certainly, if a chemist, however great his genius, had been questioned as to the nature of organic substances, before this new path of knowledge had been opened, he never would have imagined, we are certain, any thing worthy to be compared with these simple, regular, and beautiful laws which experiment has displayed to us within these few years.

To produce, with three or four elements, combinations as varied, and perhaps even more varied, than those which compose the whole mineral kingdom, nature has adopted a means as simple as unexpected; for with these elements she has made compounds, which themselves possess all the properties of elementary bodies. And this, we are convinced is the secret of organic chemistry!

Thus, organic chemistry possesses elements peculiar to it, which sometimes play the parts which chlorine or oxygen perform in the mineral kingdom, and which sometimes, on the contrary, perform the functions of the metals. Cyanogen, amidine, benzule, the compounds with ammonia for their base, fats, alcohols, and similar bodies; these are the true *elements* on which organic chemistry operates, and not upon the *ultimate elements*, carbon, hydrogen, oxygen, and azote; elements which only come forth when all trace of organic origin has disappeared.

Inorganic chemistry comprises all those bodies which result from the direct combination of *elements* properly so called.

Organic chesmitry, on the contrary, comprises all the beings formed by compounds, acting as elements would do.

In the former the bases are simple, in the latter they are compound, that is the sole difference.—(From a *Memoir on Organic Chemistry*, by MM. Dumas et Liebig.)

Aurora Borealis in London.

SUNDAY, the 12th ult., was remarkably fine, a cold wind which blew from the N.W. in the early part of the day declined in the afternoon, and the sun set with a splendour, in a nearly cloudless sky, that is rarely witnessed in this month; the moon, which was at the full, and the planet Venus, but recently passed her conjunction, presented an assemblage of beautiful objects to the lover of Nature. As soon as the sun had completely set, an Aurora was visible from the N.W. to the N.E., of extraordinary brilliancy and variety, presenting a succession of arches reaching from about 10° above the horizon to within 20° of the zenith, and occasionally completing the arch by uniting at that point; it continued for about three quarters of an hour, and died away gradually at half-past six o'clock. The rest of the night was fine, but more cloudy; on the following day, the 13th, a steady rain began at two o'clock P.M., the barometer having fallen about ·2 inch.

New Allocation of the Botanical Order Orobanchaceæ.

DR. LINDLEY communicated a paper to the British Association at Liverpool on this order, in which he states very sufficing reasons for changing its place in the natural system; he pointed out new affinities for it due to peculiarities of structure, of higher importance than those which have hitherto caused it to be ranked next to the order *Scrophularaceæ*. This station was assigned to Orobanche in consequence of its monopetalous, didynamous flowers, and bicarpellary polyspermous fruit. Dr. Lindley has lately been calling the attention of botanists to the injurious tendency of considering monopetalous structure as of more than *generic* importance; and having clearly proved this by numerous examples of intimate affinities being violated by adherence to the common views on this subject, he called attention to the fact, that the carpella in the Orobanche, instead of being *posterior and anterior*, with regard to the axis, as they are in *Scrophularaceæ*, are lateral, as is the case in *Gentianaceæ*. From the constancy of this character in those orders in which it is found, it ought justly to be considered of primary importance; and when to this is added the fact, that the seeds of Orobanche are *albuminous*, i. e., the albumen constitutes the greater part of the bulk of the seed, as is the case with those of Gentianaceæ, while the seeds of all the Scrophularaceæ are *exalbuminous*, there can be no doubt that Orobanchaceæ should be separated from the latter order, to be placed next to the former, of which it may be considered a didynamous form.

Considering the agreement in the albuminous character of their seeds, and in their leafless, scaly, brown, parasitical habits, between *Monotropæ* and *Orobanche*; and further that the order Pyrola, in which the genus Monotropa has hitherto been placed, approaches Gentianaceæ in more important characters than those by which it is allied to Ericaceæ, Dr. Lindley further proposes placing Pyrolaceæ, (including Monotropæ,) Orobanchaceæ and Gentianaceæ next each other.

The professor's paper contained some curious observations on the placentation of Orobanchaceæ, from which he infers that the admitted rule that the placentæ belong to the ventral suture does not hold good, and it must be acknowledged that the position of the placentæ is reducible to no rule but depends on specific organization, as might be inferred from the anomalous placentation of Cruciferæ, Papaver, Parnassia, &c.

The paper is highly interesting; the reader may refer to it in the November number of the *London and Edinburgh Philosophical Magazine*.

Curious Blunder.

THE *Echo du Monde Savant* gives us the following information.

"M. Babbage has just *published at Bridgewater, a Treatise* on the application of a calculating machine, of which he is the inventor."

We need hardly point out the source of this mistake, Mr. Babbage's *Bridgewater Treatise* having been interpreted as implying a treatise published *at the town* of that name.

Action of Cold Air in maintaining Heat.

I was at Sheffield in last December, and then a Mr. Linley, bellows maker of that town, showed me the following curious experiments. First, a rod of iron, about an inch in diameter, was heated at one end in a forge fire, up to a full white heat, then quickly withdrawn from the fire and exposed to a strong blast of cold air from a forge bellows; the iron immediately became so hot as to fuse, and the liquified matter was blown off and burnt in the air, with the scintillating appearance of iron-wire burning in oxygen gas: and so continued to melt until a pound or more of the metal had been thus wasted.

Another mode of producing the same action, consisted in heating a rod of iron as before, but instead of a blast of air, it was tied to a cord, and by it whirled round in a vertical plane; thus, by passing swiftly through the cold air, it melted, and was thrown off in beautiful scintillations, appearing as luminous tangents to the circle in which the bar was moved.

I have since applied a heated bar of iron to the periphery of a revolving wheel, and by an including tin hoop or guard, it is thus made an interesting class experiment.

The cause of this augmentation of temperature is, I conceive, referable to the oxidation of the metal, which takes place freely under the conditions of the experiments here recorded. Then, as is well known, the formation of the oxide is accompanied with a great development of heat; and the cases before us are striking examples of the heating influence by chemical action, predominating over the cooling effect of the air, conjoined with the radiating force. (*Philosophical Magazine*, No. 69. for Nov. From a letter to the Editor.)

"*Falling Stars.*"

When more information on the subject of this periodical phenomenon has been obtained, a more rational name will be conferred on it; but as yet the above is that by which it is still popularly known in this country, and we therefore employ it.

It appears that, on the 10th of August, a violent storm visits Constantinople annually, a city remarkably exempt from such visitations.

In addition to the notices alluded to in our last number, we have to state that M. Wartmann has sent M. Arago the following details on the "falling stars" of August, 9th and 10th ult. Two persons travelling towards Argentière, at nine at night on that day, saw in the west, within half an hour, the sky being cloudless, more than forty of these meteors, of such extraordinary brilliancy as to illuminate objects during their transit.

At Geneva, on the same night, the sky clear, and a light wind blowing from the north, between the hours of nine and midnight, forty-two "stars" were counted, but in different points of the heavens.

M. Wartmann also observed at Geneva, at that epoch, a singular phenomenon possibly connected with this subject. Large continuous masses of black clouds, violently agitated, appeared in the horizon, while over-head the sky was perfectly clear, when a shower of large drops of *warm* water fell on different points of the city.

M. Tharaud relates in a letter to M. Arago, that, in 1832, during the night of the 11th and 12th of November, the workmen engaged in emptying the coffer-dams of the bridge at Limoges, perceived a succession of "falling stars," which soon became so numerous as to alarm the men, who abandoned their work to return to take leave of their families, expecting some dreadful catastrophe.—*Echo du Monde Savant*, Oct. 25, 1837.

Salts acted on by Light.

Dr. Draper, in his papers on "Experiments on Solar Light," published in the *Journal of the Franklin Institute*, gives the following list of "all the metallic salts at present known, in the constitution of which, changes are brought about by exposure to the sun."

1. Sulphate of Nickel.
2. ——— Uranium.
3. Nitrate of Bismuth.
4. ——— Silver.
5. ——— Uranium.
6. Carbonate of Lead.
7. ——— Nickel.
8. Bromate of Silver.
9. Sulphocyanate of Iron.
10. ——— Silver.
11. Chloride of Manganese.
12. Chloride of Uranium.
13. ——— Copper.
14. ——— Mercury.
15. ——— Silver.
16. ——— Gold.
17. ——— Osmium.
18. ——— Potassium.
19. Bichloride of Mercury.
20. Iodide of Mercury.
21. Bromide of Silver.

The changes which these bodies experience are of different kinds; some become black, some bleach, some, as the sulphate of nickel, undergo changes of crystalline arrangement.

Singular Action of the Solar Rays.

THE sun's rays have the power of causing vapours to pass to the perihelion side of vessels, in which they are confined, but, as it would appear, not at all seasons of the year. For example, I have a certain glass fitted up for making these observations, and in this vessel, during the months of December, January, and part of February, 1836-37, a deposit was uniformly made towards the sun; during the months of March, April, and part of May next following, although every part of the arrangement remained, to all appearance, the same, yet the camphor was deposited on the side furthest from the sun. From May until the present date, the deposit is again towards the sun. It does not appear that any immediate cause can be assigned for this waywardness. Does it exist in the sun's light? or in changes affecting the earth's atmosphere? or in imperceptible changes in the instrument with which the observation is made? as respects the latter, I think a negative answer may be given without any hesitation; but beyond a mere expression of the fact that these anomalous circumstances do occasionally occur, I would not be understood to speak decisively; if periodic changes like this do occur, which is doubtful, they have not been watched for a sufficient length of time, nor have I made sufficient variations in my trials to be able to refer them to any distinct cause. A large bottle containing camphor, which has been deposited therein for more than a year under ordinary atmospheric pressures, has uniformly showed a crystallization towards the light.

For making these experiments properly, it is necessary to possess an air pump receiver, ground so true, as to be able to maintain a vacuum for several hours, or even days. A less perfect jar may be made to answer, by fastening it down to the pump-plate with cap cement, it will, however, be liable to leak when the cement becomes warm by exposure to the sun. For many of these trials, a barometer tube is sufficient. Those who are provided with a good pump and jars, accompanied with their proper transfer plates, will have no difficulty whatever.

Upon the plate of the pump, or one of the transferers, place some camphor in a watch-glass, supported by a stand; over this place a bell-jar, and exhaust until the difference of level of the siphon gauge amounts to half an inch or less; the further the rarefaction is pushed the better; remove the arrangement into the sunshine. In the course of five minutes, if the atmosphere be clear and the sun bright, small crystalline specks will be found on the side nearest to the sun, these continually increase in size, and at the end of two hours, many beautiful stellated crystals, from one-eighth to half an inch in diameter, will be found on that side, but on the other parts of the glass, only a few straggling ones here and there. Sometimes, as is the case in a result which I keep by me, the whole side next the sun is covered with a lamina of camphor, the other side containing none at all.—(From DR. DRAPER's Paper in the *Journal of the Franklin Institute*, No. 2, Vol. XX.)

Different Species of Silkworms.

The silk imported from India is by no means the production of the larva of only one species of moth. MM. Helfer and Hugon have given the following list of the insects, the silk of which is known in commerce.

1. *Bombyx mori.* The common silkworm.

2. *Bombyx religiosæ,* (Helf.) Assam. The cocoon of this phalæna has a finer filament, more gloss, and is softer to the touch than that of the former. The larva lives on the banyan tree, (*Ficus religiosa.*)

3. *Saturnia silhetica,* (Helf.) is found in the mountains near Silhet and Dacca; the cocoons are very large.

4. *Saturnia paphia,* (Linn.) The most common of the Indian silkworms. The silk most highly prized in Europe is its produce. In its wild state the larva feeds on the jujube plant, (*Zizyphus jujuba,*) and on the *Terminalia alata,* from which the inhabitants gather the cocoons. It has not been reared in Europe, but M. Helfer found that it could bear domestication well.

5. *Saturnia assamensis,* (Helf.) from Mooga in Assam. Its larva is found on the *Laurus obtusifolia* and the *Tetranthera macrophylla.* This insect produces five generations in the year; the cocoons collected twice during the Winter, are the finest and most abundant.

6. *Phalæna cynthia,* (Drury) a species commonly reared throughout Hindoostan for producing silk: the larva feeds on the *Ricinus,* grows rapidly, and is very hardy; its silk is coarse, but strong, so that a dress made from it lasts for more than a person's life, and such dresses are transmitted from mother to daughter.

It is commonly considered that Indian is inferior to European silk, but this arises more from the slovenly way the worms are reared in the East than from any inferiority in the staple. Attention is now much attracted to the subject in India, and ere long this produce will most probably rival in quality that from Italy.

Patent-Law Grievance. No. XXI.

The inventors of this country, and the introducers of inventions of other countries into this, were obliged to pay down to the attorney-general and other agents, &c., of the Government, during the ten years ending December, 1834, more than £313,000, and during the past year above £42,000 (being at the rate of £420,000 in ten years.) It is to be observed that these enormous extortions are *exclusive* of the drawings, engrossings, and all the other charges of the patent-solicitor.

The penalties inflicted on the inventive genius of Britain during the *present* year, up to the 25th ult., in the shape of government stamps and fees on patents, amount to more than £37,000!

N.B. This sum has been paid in *ready money* on taking the first steps, and as many of the inventors are poor men, (*Operatives,*) and a great many others of them persons to whom it would be very inconvenient to pay at least £100 down, they have been obliged to go into debt, or mortgage or dispose of their inventions, either wholly or in part, &c.

NEW PATENTS. 1837.

N. B.—The first Date annexed to each Patent, is that on which it was sealed and granted; the second, that on or before which the Specification must be delivered and enrolled.——The abbreviation *For. Comm.*, signifies that the invention &c., is "a communication from a foreigner residing abroad."

November.

185. Joseph Whitworth, Manchester, *Lanc.*, Engineer; for certain improvements in locomotive and other steam-engines. Nov. 2.—May 2.

186. Richard Burch, Heywood, *Lanc.*, Engineer; for certain improvements in manufacturing gas from coal. Nov. 2.—May 2.

187. Joseph Lockett, Manchester, *Lanc.*, Engraver; for certain improvements in the art of printing calicoes and other fabrics of cotton, silk, wool, paper, or linen, separately or intermixed. Nov. 2.—May 2. *For. Comm.*

188. James Gowland, Leathersellers-buildings, in the parish of Allhallows-in-the-Wall, *Lond.*, Watch and Chronometer Maker; for certain improvements in the mechanism of time-keepers. Nov. 2.—May 2.

189. Richard Joshua Tremonger, Wherwell, *Hants.*, Esq., for an improved spring, or arrangement of springs for wheel-carriages. Nov. 4.—May 4.

190. John Upton, New-street, Southwark-bridge, *Surry*, Engineer; for an improved method or methods of generating steam-power, and applying the same to ploughing, harrowing, and other agricultural purposes, which method or methods is or are also applicable to other purposes, to which the power of steam is or may be applied. Nov. 4.—May 4.

191. Ernst Adolph Ortman, of Stockholm, Sweden, now of Ebenezer-place, Limehouse, *Middx.*; for methods of freeing, wholly or partially, wooden or other porous vessels from certain foreign matters or substances which they are liable to absorb, and of turning to a useful account the foreign matters or substances so liberated or extracted. Nov. 4.—May 4.

192. George Deakin Midgley, Strand, *Middx.*, Chemist, and John Howard Kyan, Cheltenham, *Glouc.*, Esq.; for an improved mode of extracting or obtaining ammoniacal salts from liquor produced in the manufacture of coal-gas. Nov. 4.—May 4.

193. William Arthur, Glasgow, *N. B.*, Machine Maker; for improvements in spinning hemp, flax, and other fibrous substances. Nov. 4.—May 4.

194. Tobias Michell, Kingsland-green, *Middx.*, Gent.; for improvements in washing or purifying smoke and vapours evolved from furnaces of various descriptions. Nov. 7.—May 7.

195. Thomas Hughes, High Holborn, *Middx.*, Truss Maker; for an improvement in stocks, cravats, or stiffeners. Nov. 7.—May 7.

196. Charles François Edward Aulas, 38, Grande Rue Verte, Paris, *France*, but now of Cockspur-street, *Middx.*, Gent.; for a new and improved method of cutting and working wood by machinery. Nov. 7.—May 7. *For. Comm.*

197. John Potter, Ancoats, Manchester, *Lanc.*, Cotton-spinner; for improvements in the process of preparing certain descriptions of warps for the loom. Nov. 9.—May 9.

198. James Slater, Salford, *Lanc.*, Gent.; for certain improvements in steam-engines, and also in boilers and in furnaces used for the generation of steam, or other useful purposes. Nov. 9.—May 9.

199. Charles Wye Williams, Liverpool, *Lanc.*, Gent.; for certain improvements in the means of preparing the vegetable material of peat-moss, or bog, so as to render it applicable to several useful purposes, and particularly for fuel. Nov. 11.—May 11.

200. Henry Crosley, Hooper-square, *Middx.*, Civil Engineer; for improved means to be employed in manufacturing beet root and other vegetable substances for the purpose of obtaining saccharine matter therefrom. Nov. 11.—May 11. *For. Comm.*

201. Hamer Stansfeld, Leeds, *York.*, Merchant; for certain machinery of a tappet and lever action, to produce a vertical or horizontal movement, through the medium of ropes, or bands, working over, under, or round pulleys. Nov. 14.—May 14. *For. Comm.*

202. William Coles, Charing Cross, *Middx.*, Esq.; for improvements in gunnery and in gun and other carriages, and in the means of connecting the same. Nov. 14.—March 14.

203. Robert White, Nottingham, *Notts.*, Lace Maker; for improvements in the manufacture of ornamental lace. Nov. 14.—May 14.

204. Robert Whitfield, Hercules-

buildings, Westminster-rd., *Surry*, Gent.; for a composition which he denominates an indelible safety and durable black fluid writing-ink. Nov. 14.—May 14.

205. John Jeremiah Rubery, Birmingham, *Warw.*, Umbrella Furniture Manufacturer; for certain improvements in the manufacture of part of the furniture of an umbrella. Nov. 14.—May 14. *For. Comm.*

206. Joseph Birch Mather, *Notts.*, Mechanic and setter up of Hosiery Frames; for certain improvements in machinery employed in manufacturing hosiery goods, or what is commonly called frame-work knitting. Nov. 14.—May 14.

207. William Neale Clay, West Bromwich, *Stafford.*, Manufacturing Chemist; and Joseph Denham Smith, St. Thomas's Hospital, Southwark, *Surry*, Student in Chemistry; for certain improvements in the manufacture of glass. Nov. 16.—May 16.

208. William Herapath, Bristol, *Somerset.*, Philosophical Chemist; and James Fitchew Cox, of the same place, Tanner; for certain improvements in the process of tanning. Nov. 16.—May. 16.

209. William Fourness, Leeds, *York.*, Painter; for improvements in ventilating pits, shafts, mines, wells, ships' holds, or other confined places. Nov. 16.—May 16.

210. James Buckingham, Miners-hall, Strand, *Middx.*, Civil Engineer; for certain improvements in the means of ventilating mines, ships, and other places, and an apparatus for effecting the same. Nov. 16.—May 16.

211. Thomas Birch, Manchester, *Lanc.*, Machine Maker; for certain improvements in carding-engines, to be used for carding cotton and other fibrous substances. Nov. 18.—May 18.

212. Elisha Haydon Collier, Globe Dock Factory, Rotherhithe, formerly of Boston, North America; for certain improvements in machinery applicable to the raising fluids and other bodies. Nov. 21. —May 21.

213. Christopher Nickels, Guildford-st., Lambeth, *Surry*, Gent.; for improvements in embossing or impressing the surfaces of leather and other substances, applicable to various purposes. Nov. 21.—May 21.

214. Elisha Wylde, Birmingham, *Warw.*, Engineer; for certain improvements in locomotive and other engines. Nov. 21.—May 21.

215. James Matley, Paris, *France*, and Manchester, *Lanc.*, Gent.; for certain improvements in Machinery for the operation of tiering, used in printing cotton, linen, and woollen cloths, silks, papers, and other articles and substances to which block printing is or can be applied. Nov. 23.—May 23.

216. James Jamieson Cordes, Idol-lane, *Lond.*, Merchant; for an improved mortar for dressing rough rice or paddy, or redressing rice. Nov. 25.—May 25.

217. Henry Purser Haile, Oxford-st., *Middx.*, Civil Engineer; for improvements in rails for rail-roads. Nov. 25.—May 25.

218. Richard Tappin Claridge, Salisbury-st., Strand, *Middx.*, Gent.; for a mastic, cement or composition, applicable to paving and road making, covering buildings, and the various purposes to which cement, mastic, lead, zinc, or composition are employed. Nov. 25.—May 25. *For. Comm.*

219. Samuel Cocker, Porter-works, Sheffield, *York.*, Manufacturer; for improvements in making needles. Nov. 25. —May 25.

220. Samuel Draper, Basford, *Notts.*, Lace Maker; for certain improvements for producing ornamental lace or weavings. Nov. 27.—May 27.

221. Thomas Moore, Ison-green, *Notts.*, Lace Manufacturer; for improvements in machinery for frame-work knitting. Nov. 27.—May 27.

222. William Jones, Bartholomew-close, Chemist; and John Dover, Thames-st., *Lond.*, Merchant; for improvements in filtering fluids.—Nov. 28.—May 28.

METEOROLOGICAL JOURNAL FOR OCTOBER, 1837; KEPT AT BLACKHEATH ROAD.

Day of Month		Barom. 9 A.M.	Ther. attch.	Barom. 3 P.M.	Ther. attch.	Thermometer Min.	Thermometer Max.	Daily Temp.	Solar Var.	Rad.	Clouds. A.M.	Clouds. P.M.	Winds A.M.	Winds P.M.	Direction of Wind A.M.	Direction of Wind P.M.	Lunation.	WEATHER, &c.
Sun.	1	29·984	65°	29·986	67°	51°3	66°8	59°1	15°5	48	10	4	1	1	S	SSW		Damp, with small rain; *close.*
Mon.	2	30·182	64	30·286	68	53·0	67·1	60·1	14·1	49	8	8	1	1	WSW	WSW		Cloudy, with light drizzling showers.
Tues.	3	30·211	65	30·142	70	50·9	67·8	59·4	16·9	47	4	2	1	1	SSW	S		Misty, A.M.; *cirro-cumuli;* warm.
Wed.	4	30·085	69	30·136	71	57·6	68·0	62·8	10·4	54	8	3	2	2	WSW	WNW		Dark and cloudy, till 10 A.M.; fine; great deposition
Thurs.	5	30·295	68	30·274	68	48·2	63·5	55·6	15·3	44	5	6	2	2	W	WSW		Mostly cloudy; evening overcast. [of moisture.
Friday,	6	30·130	67	30·132	69	51·2	63·9	57·6	12·7	49	7	3	2·3	2	W	W		Rain in heavy showers, till 9½ A.M.; fine.
Satur.	7	30·285	65	30.266	67	46·6	60·6	53·6	14·0	43	7	6	1	0	wly	Nly.	☽	Thick; misty. } *great deposition of moisture, and but little evaporation these four days.*
Sun.	8	30·250	65	30·162	66	46·0	62·0	54·0	16·0	44	10	9	2	1	SW	W		Cloudy; rain at 3 P.M.
Mon.	9	30·351	62	30·349	63	43·1	56·5	49·8	13·4	40½	4	3	1	2	NW	NW		Fair.
Tues.	10	30·402	62	30·396	64	42·2	60·9	51·6	18·7	40	7	7	1	1	W	W		Ditto.
Wed.	11	30·438	63	30·440	64	50·9	62·6	56·7	11·7	49	8	5	1	1	SW	SW		Very fine.
Thurs.	12	30·504	62	30·504	65	46·0	60·4	53·2	14·4	43	4	7	0	1	W	NNE		Hazy; alternately clear and cloudy.
Friday,	13	30·642	61	30·650	63	40·2	55·8	48·0	15·6	38	1	7	1	1	NE	NE	○	Clear at intervals; *cumuli* into *cirro-cumuli.*
Satur.	14	30·752	60	30·726	63	40·1	54·0	47·1	13·9	37	4	0	1	1	ENE	NE		Very fine; calm and serene; fog at night.
Sun.	15	30·700	67	30·624	60	31·9	52·8	42·3	20·9	30	1	3	1	0	Nwly.	NW		*Hoar frost;* misty; cloudy at night.
Mon.	16	30·549	57	30·461	59	39·0	53·9	46·4	14·9	36½	7	8	1	0	NW	WNW		*Cirro-cumulus;* overcast. *Swallows last seen.*
Tues.	17	30·318	57	30·215	59	37·5	55·6	46·5	18·1	35	5	10	1	1	W	wly.		Morning fog. Cloudy.
Wed.	18	30·158	58	30·170	59	47·8	59·1	53·5	11·3	45	5	9	1	1	W	WNW		*Light nimbi;* a shower at noon; cloudy.
Thurs.	19	30·438	58	30·452	59	37·0	55·9	46·8	18·9	35	5	5	1	1	W	W		Fine.
Friday,	20	30·586	59	30·595	62	42·8	60·8	51·8	18·0	39	2	5	2	2	W	WNW		Very fine; *Sun out all day.*
Satur.	21	30·692	60	30·640	62	45·9	56·8	50·9	11·8	42	9	7	0	0	wly.	wly.	☾	Overcast; misty and calm. } *The trees still in full leaf.*
Sun.	22	30·501	61	30·421	63	43·1	58·5	50·8	15·4	40	7	9	1	1	wbs	WSW		Cloudy; *cirro-cumuli.*
Mon.	23	30·106	62	29·950	63	51·2	61·2	56·2	10·0	49	8	7	2	3	WSW	SW		Ditto, ditto. Air, turbid and cloudy.
Tues.	24	29·659	62	29·540	63	48·5	53·4	51·0	4·9	48	10	10	0	1	WSW	NW		Rainy night; dense *cum.-strati* and *nimbi,* with heavy
Wed.	25	29·720	57	29·886	57	33·6	48·1	40·8	14·5	32	10	5	1	2	N	NW		Rain, from 9 to 11, A.M.; sharp and cold. [showers.
Thurs.	26	30·100	54	30·001	54	31·0	51·4	41·2	20·4	29	8	8	2	3	WSW	WSW		Hoar frost; flimsy clouds; night cloudy, with a gale.
Friday,	27	29·548	56	29·575	57	49·0	53·6	51·3	4·6	45	10	5	3	2	SW	wbs		Rain and wind in heavy squalls, till noon, P.M.; clear.
Satur.	28	29·655	54	29·476	55	37·9	51·9	44·9	14·0	34	8	10	2	0	SSW	S		Overcast; a wet afternoon; *about half an inch fell.*
Sun.	29	29·526	54	29·508	58	35·2	47·2	41·2	12·0	34	0	7	1	1	wbs	SW	●	Morning very clear; evening cloudy, with showers.
Mon.	30	29·420	57	29·274	58	36·6	58·3	47·5	21·7	34	10	9	2·4	3	sbw	SW		Rain and wind in squalls. *The foliage of trees change.*
Tues.	31	29·400	56	29·448	57	41·5	48·4	44·9	6·9	40	6	3·3	3	2	W	W		Clear; distant *nimbi; lightning to the east at night.*
Mean.		30·180	61	30·146	63	43·74	57·96	50·86	14·22									

Bar. Max. 30·752 on the 14th.
Bar. Min. 29·250 " 30th.

Ther. Max. 68·0° on the 4th.
Ther. Min. 31·0° " 26th.

Lowest point of Rad. 29°, on the 26th.
Rain fallen (by Crossley's self-registering gauge), 2·614 in.

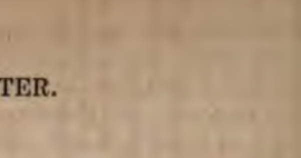
THE HYDROMETER.

II.

HAVING now treated of the principal properties of liquids which influence their density, we will proceed to describe various contrivances which have been devised for measuring variations in that density. The details just given relate, for the most part, to the density of solids, but it is important to bear in mind, that the density, or specific gravity, of liquids is, in almost all cases, however different in minor details, ascertained by the depth to which a solid will sink in them.

Before proceeding to a description of hydrometrical instruments, we will at once show, by two figures, the difference between ascertaining the specific gravity of liquids, and that of solids. First, let us speak of solids. We have three cubical pieces of different substances, but of the same size,—say one inch cube. We immerse them in a given liquid,—say water, and we see that A (fig. 2) sinks to one quarter of an inch below the surface, D E, B to half an inch, and C sinks wholly below the surface, and floats about indifferently in every part. We then know that A has displaced one quarter of a cubic inch of water, and as that equals the whole weight of the body, we say that the density, or specific gravity, of water is four times that of the solid, or, if water be 1000, the solid is 250. B displaces half a cubic inch of water, and is therefore to water as two to one in bulk, or as half to one in density, thus giving 500 as its specific gravity. As C sinks wholly below the surface, but is indifferent to position in other respects, its specific gravity is equal to that of water. If, however, C do not remain suspended, but fall to the bottom, the force of that tendency, or its weight in water, must be added to the specific gravity of the water, to get its real specific gravity.

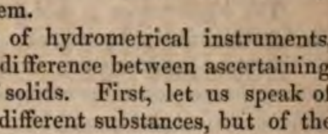
Fig. 2.



But now, to measure the specific gravity of liquids, one solid and two or more liquids must be employed: in the former case, one liquid and two or more solids were necessary. If this difference be borne in mind, it will show at once the difference of the principle employed.

We have three liquids (fig. 3), *a a*, *b b*, *c c*, the comparative densities of which we wish to determine; we take a solid of a definite size and weight, A, which, when placed on water, sinks to half its depth, as in *a a*. This (water being the most convenient standard) is assumed as a standard; it matters not to what depth it sinks, but we have assumed half its height, for convenience of illustration: the density, then, of that liquid is double that of the solid. The solid is then placed on the second fluid, *b b*, but it sinks only one quarter

Fig. 3.



of its bulk, thus snowing that the density of that fluid is four times that of the solid. In the third liquid, *c c*, three quarters of the solid sinks, which indicates that the density of the liquid is to that of the solid as four to three. If, therefore, the density or specific gravity of *a a* be taken as a standard, and called 1, that of *b b* will be 2, and that of *c c*, 0·666.

The reader will at once perceive the difference between these two modes of experiment. To ascertain the specific gravity of solids, they are all weighed in one given liquid, as before detailed; but to measure the specific gravity of liquids, one given solid is immersed in them all; and the different modes of measuring that immersion we will now proceed to describe.

The hydrometer is said to have been invented towards the end of the fourth century, by Hypatia, a lady celebrated for her acquirements in literature and science, a distinction which, unhappily for herself, excited the envy of her contemporaries, and to this she fell a victim during an insurrection at Alexandria. She contrived this instrument as a means of ascertaining the purity of water, upon the principle of floating bodies discovered by her immortal and equally unfortunate predecessor, Archimedes.

It has been already explained, that a body floating in water displaces a portion of the fluid precisely equal to its own bulk; that as the density of water increases with the depth, a solid would continue to sink until its own density and that of the water corresponded; or, what is the same thing, a solid floating in different liquids, of different specific gravities, would settle at various depths in all of them, and that, in proportion as the density of a liquid is small, the corresponding depth to which the solid would sink would be increased. It evidently follows, too, that another solid, capable of floating on water, would, in order to float on a lighter fluid, displace more of the latter than of the former, and a larger portion of the solid would be submerged.

It is a common remark, that it is easier to swim in salt than in fresh water, and the remark is just, because the density of the one is greater than that of the other. A common test of the quantity of salt necessary to add to water, in making brine for pickling meat, is to continue to add salt until an egg will swim in it[*]. This seems to have suggested the idea of the hydrometer, which consists of a hollow brass ball in the form of an egg, with a stem proceeding from the larger end and another from the smaller, which latter bears a weight to preserve the stability of the instrument in liquids. This, then, is the common form of the hydrometer, and if it be placed in a tall vessel of pure water, the oval part, together with a portion of the stem, will sink: a line, therefore, may be drawn upon the stem, corresponding with the surface of the water, and a number of equal divisions being drawn above and below this standard mark, the depth to which the stem sinks will show whether any other liquid into which the instrument is placed is lighter or heavier than water: thus, in alcohol, it would sink so low as to submerge nearly the whole of the upper stem, while in salt water it would rise so as to leave the water-mark considerably above the liquid surface.

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[*] This, however, is a very bad test, incapable of indicating the strength of brine, since an egg will float in a saturated solution of salt and water, and will also float, if, to the same saturated solution, a bulk of pure water equal to twice the bulk of the latter be added. According to Gay-Lussac, seven ounces and a half of salt are necessary in order to saturate an imperial pint of water at 60°, whereas if to this pint, two pints of pure water be added, the resulting solution will have a specific gravity of 1·078 at 60°, which is the average specific gravity of an egg at the same temperature. This is important, since the efficacy of brine in preserving meat depends very much upon getting a solution of salt at the exact point of saturation.

Before we proceed, we will again remind the reader, that the action of this instrument depends solely upon the displacement of a bulk of water equal to that of the submerged portion of the instrument; that the displaced liquid endeavours, so to speak, to recover its place, and does so by pushing up the solid (for in geometry a hollow ball is as much a solid as if it were an unbroken mass of metal) which displaced it, and the solid is pushed up until the effort of the water is balanced by the effort of the solid to sink. Equilibrium is now established, since the weight of the instrument, from the water-mark downwards, and the weight of the water displaced, are the same.

Philosophers have considered the particles of water to be round, and consequently to present a number of vacant spaces, or pores, since two spheres can only touch each other at one point; and that when a body is dissolved by water, it enters into these vacant spaces or pores, and so increases the density of the whole. This theory, however, must be received with caution, inasmuch as we really know but little of the molecular constitution of matter, but it is supported by some facts, which, as they are striking and applicable, we may briefly mention.

The solvent power of warm water is greater than that of cold, (with one remarkable exception, noticed by Dalton, viz., that more lime is taken up in solution by cold than warm water,) because, as it occupies more space than cold water, it is inferred that the globular atoms are removed to a greater distance, and that the spaces between the atoms being increased, the substance dissolved is taken up in larger quantity, and, in most cases, if the warm liquid be saturated with a soluble substance, a portion of the latter is thrown down in a solid state as the liquid cools.

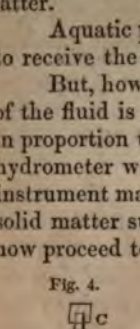
If a pint of sulphuric acid and a pint of water be mixed, the result will be considerably less than a quart; the same remark applies to strong spirit and water, and many other substances among metals as well as liquids.

When a solid is dissolved in a liquid, the bulk of the latter is not always increased. Water will dissolve a portion of common salt, and afterwards another portion of sugar, without increase of bulk. A common illustration of this fact is to suppose a vessel filled with cannon-balls; the vacant spaces would evidently receive a large number of shot, and the spaces formed by the latter would admit a portion of sand. So the water having dissolved the salt, the particles of the latter are smaller than those of water, and lie between them, as the shot lies between the cannon-balls; and the particles of the sugar, being smaller than those of the salt, will, like the sand among the shot, insinuate themselves into spaces too small for the admission of the salt. It is worthy of remark, that no substance ever dissolves in water without a change of temperature in the latter.

Aquatic plants have their pores round, and so are adapted, it is said, to receive the same shaped particles of water upon which they live.

But, however it may be, one thing is certain, viz., that the density of the fluid is increased by the addition of a soluble substance, and that, in proportion to the weight of the substance employed, the stem of the hydrometer will stand higher than in pure water, and the scale of the instrument may be so graduated, as to indicate precisely the quantity of solid matter suspended by the water. The methods of effecting this we now proceed to detail.

Fig. 4.



The accompanying figure (fig. 4) represents *Sikes's hydrometer*, which is the one ordered by Act of Parliament to be employed in collecting the revenue on ardent spirits. It consists of a brass ball, A, whose diameter is $1\frac{6}{10}$ inch, into which is inserted a conical stem, F, about $1\frac{8}{10}$ inches long, terminated in a pear-shaped bulb, B, which is loaded, in order to give the instrument stability in water. At D is inserted a flat stem, $3\frac{4}{10}$ inches long, and graduated into eleven equal parts, each of which is subdivided into two. This instrument is accompanied by eight circular weights, such as E, in which a slit is cut, so as to admit the thinner part of the conical stem at F into the hole in the centre of the weight, which then slides down to D. These weights are marked with the numbers, 10, 20, 30, 40, 50, 60, 70, and 80, and their use is to adapt the instrument to liquids heavier than water, because, without this, the ball would not sink low enough to allow the scale to be of service. When one of these weights is employed, the number marked on it must, of course, be added to, or subtracted from, that on the scale, as the case may be; but excise officers, in addition to the instrument, are furnished with a set of tables, accompanied by a few simple rules, by which the specific gravity of a spirit is easily ascertained when its temperature is known*; and for this purpose a thermometer always accompanies the instrument.

Another form of the hydrometer consists in having a second and smaller ball to screw to the large ball at F (fig. 4); this second ball is hollow, and, by means of shot within it, so adjusts the instrument as to cause the whole to weigh 4000 grains. The scale C D is graduated into inches and tenths of inches, and weights so low as tenths of grains are furnished, to be placed on the top of the stem at C, by which means the instrument may be brought to sink always to one certain division on the scale. Now, when the hydrometer is plunged into one kind of liquid, and a grain placed in C makes it sink one inch, the tenth of a grain would, of course, sink it only a tenth of an inch. If therefore, it stand in one kind of water one-tenth of an inch lower than in water of another kind, it shows that a bulk of the former weighs one-tenth of a grain less than the same bulk of the latter, which gives a difference in specific gravities between the two fluids of one part in 40,000.

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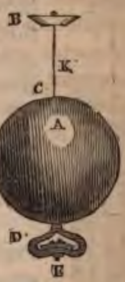
* So much is the specific gravity of alcoholic liquors affected by change of temperature, that a cubic inch of good brandy is ten grains heavier in winter than in summer, the weight in summer being four drachms thirty-two grains, and in winter, four drachms forty-two grains; so that thirty-two gallons of spirit in winter will measure thirty-three gallons in summer. Spirit merchants, &c., seem aware of this fact, and contrive to make their large purchases in winter, and to effect their sales in summer.

Fig. 5.



The hydrometer of Nicolson (fig. 5) is an improvement upon one constructed by Fahrenheit, and is too important to allow us to pass by without giving it a particular description. It consists, as before, of a hollow brass or copper ball, A, to which, by means of an extremely thin steel wire, is attached a cup, B. A stirrup, D F, contains also a dish, F, and weights made sufficiently heavy to cause the wire, C, to be vertical when the instrument is immersed in a liquid. The instrument is so adjusted, that when 1000 grains are placed in the cup B, in distilled water at 60°, it sinks down to a point K marked on the wire. The quantity, therefore, of liquid displaced, is equal to the weight of the instrument, and 1000 grains in addition. Now it is quite clear, that if spirit at 60° be employed instead of water, a less weight than 1000 grains will suffice to sink the instrument to D; knowing what this weight is, we get the weights of equal volumes of spirit and of water, and we obtain the specific gravity of the spirit, by dividing one weight by the other.

By means of this hydrometer the specific gravity of solids can be determined, as well as that of liquids. Let a portion of the solid be placed in the cup B, and as many weights as will sink the wire down to K: we know then that the solid and the weights amount to 1000 grains; if, therefore, these weights in grains be subtracted from 1000 grains, we shall get the exact weight of the solid in air. If now the solid be placed in the lower cup, F, and the point K be brought down to the level of the water as before by means of weights, these weights, together with that of the solid in water, will again make up 1000 grains, and if they be subtracted from 1000, we shall get the weight of the solid in water: by dividing one weight with the other we get the specific gravity.

By means of this instrument specific gravities can be ascertained to within 100,000th part of their whole value, or to five places of decimals.

*The Aërometer** *of Parcieux* (fig. 6) is another form of the hydrometer. It consists of a glass phial or cylinder, B C, tightly corked, and into the cork is fixed a straight wire about 30 inches long. By means of shot contained within the phial the latter is made to sink in any liquid, so that about an inch of the wire above A is submerged. The liquor whose specific gravity is to be taken is put into a cylindrical vessel E F, three or four feet in height, and as many inches in diameter, and a scale of equal parts, D, is attached to the side to mark the degrees of immersion. The instrument is put into this vessel, and the specific gravities of various kinds of liquids are compared, as in the last case, by putting weights into the dish, A, until the instrument sinks down to a mark upon the wire. This instrument is so extremely sensible, that if contained in water of a given temperature, and the sun's rays be allowed to fall upon it for a few moments, it will sink through several inches in consequence of the heat of the sun's rays diminishing the density of the liquid, and it will as quickly rise again if carried into the shade. A pinch of any substance soluble in water thrown in will cause it to rise, and a drop of strong spirit poured in will cause it to sink. One of these instruments weighs about 24 ounces, and in water there is a fall or rise of about half an inch for every $\frac{1}{17424}$th part of the liquid displaced, so that a difference in the specific gravities of any two liquids can be detected to the 100,000th part.

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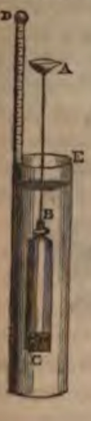
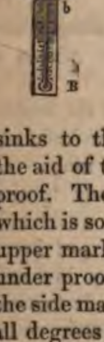
* From αηρ, air, and μετρεω, to measure.

Fig. 6.



Jones's Hydrometer (fig. 7.) This instrument is intended expressly to indicate the strength of spirit, for which it appears well calculated. It is about nine inches long from A to B: C is a hollow globe about 1½ inch diameter, and the stem A *a* is four-sided, all of which are graduated in a particular manner. The lower part, B *b*, is graduated and used as a thermometer, and made sufficiently heavy to keep the instrument upright. The limits of the instrument are from water to 74 degrees above proof,—that is, from water, containing no spirit at all, to spirit of that strength which is indicated by $\frac{74}{100}$ths stronger than the proof spirit taken as the standard of the excise. The instrument is so adjusted that when placed in spirit 74 over proof, it sinks to the last graduated line near the top of the stem, and that when in spirit 47 over proof, it sinks only to the bottom of the stem at *a*. The space then from A to *a* is divided into 27 parts, which serve to indicate, by the depth to which the instrument sinks, all strengths from 74 to 47 above proof. These are engraved on one side of the stem, marked 0 at the top. A small weight marked 1 is then placed on the top, and the strengths measured by the use of that weight are marked on another side of the stem marked also 1. When placed in spirit 46 over proof, it sinks to the highest mark, and when in 13 over proof, it sinks to the lowest, at *a*. This space is divided into 33 parts, which, by the aid of the weight on the top, indicate all strengths from 13 to 46 over proof. The weight No. 1 is then replaced by a heavier weight marked 2, which is so regulated, that, with its addition, the instrument sinks to the upper mark in spirit 12 over proof, and to the lower mark in spirit 29 under proof. This space is divided into 41 parts, which are engraved on the side marked 2, and with that weight proof spirit is indicated, as well as all degrees to 29 under proof, and all to 12 over proof. This weight is then replaced by a third still heavier, which, in a similar manner to the instances before detailed, serves to indicate all strengths from 30 under proof to 100 under proof, which is, in fact, pure water. There are other marks on the stem, to indicate a remarkable effect produced by mixing spirit with water. If to 100 gallons of spirit 66 over proof 66 gallons of

Fig. 7.



water be added, it becomes of the strength designated as proof spirit; (for that is what is meant by 66 over proof;) but the bulk of the compound is not 166 gallons,—it is only 162, it having suffered a condensation of 4 gallons in 166. If 61 gallons of water be added to 100 gallons 61 over proof, the loss is 3½ gallons: at 56 over proof = 3 gallons: at 48 = 2½ gallons: at 40 = 2 gallons: at 31 = 1½ gallons: and at 12 = 1 gallon.

The lower stem has a thermometer on each of its sides, which show what correction is to be made for temperature. The instrument is adapted for 60° Fahrenheit, and that temperature is taken for the zero of each thermometer, which is marked 0 in the middle of its height. The rest of the thermometer above and below is then graduated in a particular manner, each thermometer having a peculiar graduation of its own. If now the strength of the spirit be indicated by the stem and weight No. 2, look at thermometer No. 2, and if the mercury stand 3 divisions above the zero, subtract 3 degrees from the strength of the spirit: if the mercury indicate 4 divisions below zero, add 4 degrees to the strength of the spirit, and so on, with any height of the mercury, or any face of the instrument.

The practical applications of the hydrometer are very numerous, and the dependance which can be placed upon this beautiful instrument is, perhaps, the highest of its merits. The specific gravities of most substances in a state of purity are well known, and the taking of the specific gravity of any solid or liquid is often a sufficient test of its purity. No one, for example, could mistake between gold and copper-gilt, a simple appeal to the balance would detect the heavier of the two, but this latter would not detect pure gold from gold slightly alloyed with a baser metal; but by taking the specific gravity of one and of the other, not only can the pure gold be decided on, but the exact proportion of alloy in the adulterated gold, and in many cases the real nature of the alloy, is ascertained by specific gravity alone. Spirits in every form and variety as they occur in commerce, are a mixture of alcohol and water, and a few other bodies which determine the flavour, &c. of the liquid. Now, the value of these articles depends upon the proportion of pure alcohol contained in them; the purchaser does not want to buy water, for this he can easily and cheaply procure, and make the addition so as to suit his profit or convenience. An amusing case of adulteration of spirit is mentioned by Dr. Arnott, in his *Elements of Natural Philosophy*. "A shopkeeper in China sold to the purser of a ship a quantity of distilled spirit according to a sample shown; but, not standing in awe of conscience, he afterwards, in the privacy of his store-house, added a certain quantity of water to each cask. The spirit having been delivered on board, and tried by the hydrometer, was discovered to be wanting in strength. When the vendor was charged with the intended fraud, he at first denied it, for he knew of no human means which could have made the discovery; but on the exact quantity of water which had been mixed being specified, a superstitious dread seized him, and having confessed his roguery, he made ample amends. On the instrument of his detection being afterwards shown to him, he offered any price for what he foresaw *might be turned to* great account in his trade."

The ignorance of this Chinese of the application of the physical sciences is perhaps natural and excusable, but what shall we say to the ignorance of an European nation, once so mighty in arms, arts, and literature, but now, alas! how fallen? The following account is taken from an admirable work by the Rev. H. Moseley, on *Mechanics applied to the Arts*, wherein the principles of science are treated in so lucid and complete a manner as is seldom met with in a professedly popular work. This case, which was first mentioned by Dupin, places the commercial value of the hydrometer in a striking point of view.

"Brandies have, according to their greater or less degree of concentration, a greater or less specific gravity. The French, who first measured the degrees of concentration, by means of hydrometers, first gained by this means the advantage of being able to make their brandies always and with certainty of those precise degrees of strength which were required by the different markets to which they carried them. The Spaniards, whose strong full-bodied wines are eminently suited to distillation, endeavoured to enter into competition with the French in the sale of brandies; but as they are not acquainted with the method of measuring their degrees of concentration by means of hydrometers, they were obliged to content themselves with the following clumsy and awkward substitute. A drop of oil was allowed to fall from a given height on the surface of the brandy to be examined, and so as it was seen to sink in it, to a greater or less depth, the brandy was concluded to be of a greater or less strength. This measure failed them perpetually, and the result was, that their foreign market was supplied with brandies, on the strength of which no reliance could be placed. Spanish brandies having thus acquired a bad reputation in the market, they were purchased by the French merchants, concentrated to the requisite degree as shown by the hydrometer, and eventually resold as French. By the sale of this description of brandy in the Northern market alone, the French, before the Revolution, realized an annual profit of four millions of francs.

"The Spaniards now at length understand the use of the hydrometer, and carry their brandies to market themselves."

*The Lactometer**.—This instrument is only a modification of the hydrometer, and is employed to ascertain the specific gravity of milk, which is always somewhat heavier than water. In Switzerland and the north of Italy, the peasants sell the milk of their flocks to a large proprietor or cheese-factor, who receives it every evening, measures it, and ascertains its specific gravity. At the end of every season, each peasant receives, generally in kind, sometimes in money, the value of his milk, according to the quantity and quality which is entered to his account by the proprietor. Thus the use of the lactometer prevents fraud, since the admixture of water would make the milk lighter, which levity the instrument, and the experience of the observer, would probably detect; but considerable error is likely to ensue unless great precaution is taken in ascertaining the specific gravity of milk by means of the lactometer.

Cream is lighter than milk, so that milk rich in cream, and milk largely adulterated with water, would furnish equal results by the instrument. It has, therefore, been proposed to employ, as a lactometer, a graduated glass tube, which is to be filled with new milk, and allowed to repose for a certain number of hours, and then to note the thickness of the stratum of cream upon the surface. When all the cream is skimmed from off the milk, then the lactometer will furnish the relative amounts of curd and whey; so that observations made by both instruments furnish results tolerably correct: the one would especially apply to the making of butter, and the other to the making of cheese.

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* *Lac* is the Latin name for *milk*

The Saccharometer[*].—This, again, is only a hydrometer, applied to a particular purpose. It is known that beer, and malt liquor generally, is prepared from a grain, (barley is preferred on account of its affording a larger extract,) which, by being steeped in water for a few days, begins to germinate; it is then removed, and dried on a kiln; this constitutes malt, and during this process a saccharine principle is developed, which is also partly formed by and soluble in water at about 170°. After a few hours' repose, if this water be removed from the grain, it will be found to be viscid and sweet, according to the quantity of malt employed. This liquor, which is heavier than water, is called *sweet-wort*, and the quantity of sugar or saccharine matter suspended in it is measured by means of the saccharometer, and thus the comparative values of different malts are estimated. This sweet-wort is boiled in a copper boiler, together with a vegetable bitter, (hops afford the pleasantest bitter, and are therefore preferred,) for a considerable time; the liquor is then set aside to cool, and when it has cooled down to about 70°, a fermentable matter is added to it (called *yeast*) by which the whole mass is put into a state of active fermentation, which lasts generally three or four days, during which time a large quantity of carbonic acid gas is thrown off; the liquor becomes specifically lighter, and from a thick, turbid appearance, which it had during active fermentation, it is now finer and more transparent, but it does not become altogether so for a few weeks. This process of fermentation is technically called *attenuation*, (from *tenuis*, thin,) by which a portion of the dissolved sugar is converted into spirit, and it is the amount of this latter which gives to malt drinks the terms strong and mild. New beer is sweet, because little of the saccharine matter is converted into spirit; old beer is strong, for a converse reason. Now, it is of consequence to the brewer to know, from time to time, what progress his beers are making in the process of attenuation. This saccharometer tells him how much sugar is taken up to form spirit, and how much remains as *food* to what is left, as well as to impart or preserve flavour. This is important, since fermentation is always going on more or less in malt drinks; and when all the sugar is taken up, and what is called the *vinous fermentation* is at an end, the acetous begins, by which all his beer is converted into vinegar. Hence the sour taste of some beers in which the acetous fermentation has begun.

The Barometrical Aëriometer (fig. 8).—This is an instrument which compares the specific gravities of immiscible liquids; but, as the greater number of liquids will mix together, its application is limited. A siphon tube, A B, is supported on a pedestal, C; the two ends, A and B, are open, and the two fluids (say water and mercury) are poured in. Suppose the mercury were poured in first, it would occupy the lower part of the siphon; but when water was poured into one leg, the mercury would gradually rise in the other leg, until the line of division of the two liquids would be at C, the centre of the siphon. We should now know that equal weights of the two liquids were in the siphon, because they balanced each other. If now the height of the mercury from the level (F I) were one inch from F to D, the height of the water in the other leg from I to E would be about 13½ inches, thus indicating that the densities or specific gravities of the two liquids were as 13½ to 1. This instrument is of but little use for practical purposes, but the theory of its action will be sufficiently clear.

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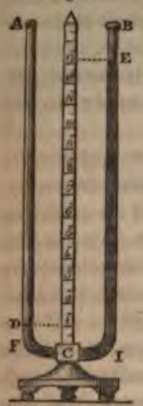
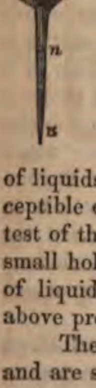
[*] Σακχαρον is the Greek word for sugar.

Fig. 8.



*Brewster's Staktometer**, or drop-measurer, (fig. 9,) is an instrument for measuring specific gravities by the size of the drops which exude from a small orifice. It consists of a stem, A B, the middle of which is expanded into a globe, C, half an inch in diameter. One point (*m*) is marked on the upper stem, and another point (*n*) on the lower stem. The vessel is then filled from B, by the action of the mouth at A, with distilled water, which is then allowed to flow out to the level, *m*. The number of drops which fall from the lower orifice is then reckoned from the level *m* to that of *n*; and that number, whatever it be, is taken as a standard. The instrument is then filled with proof spirit, and the same process is observed as with water. Thus are furnished two numbers which form the extremities of a scale: when, therefore, a diluted spirit is poured in, the number of drops is intermediate between the two limits of the scale, and serves as an indication of the proportion between the aqueous and alcoholic portions of the liquid. Thus, in one instrument, the number of drops of distilled water was 724, while the number with proof spirit was 2117; thus indicating that a drop of water was about three times the size of a drop of proof spirit, and furnishing a scale of 1393 degrees to measure different strengths of gravity.

Fig. 9.



There is another mode of ascertaining the specific gravity of liquids, which, from its simplicity, deserves notice, although not susceptible of much accuracy. We have already alluded to an old-fashioned test of the strength of brine for pickling meat, and the employment of small hollow beads with projecting tails for ascertaining the specific gravity of liquids, seems to have been suggested by the use of the egg in the above process.

These beads were first employed by Professor Wilson, of Glasgow, and are so adjusted to each other, that one of them will remain at rest in any part of a fluid of a known specific gravity; the bead has a number marked upon it which indicates this specific gravity. A series of beads is thus prepared in a decreasing or increasing order from the specific gravity of pure water. When it is required to ascertain the specific gravity of a liquid, several of these beads are thrown into it; those which sink or swim are of no account, but that which remains suspended in the liquid shows the specific gravity. The success of this plan evidently depends upon the accuracy of the graduation of the beads.

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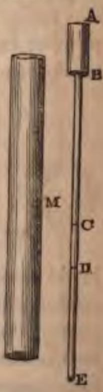
* Στακτη, or ϛαξ, signifies a *drop*.

This plan is adopted in sugar refineries with much advantage. Coarse brown sugar is reduced to a syrup, and the impurities removed by a process of filtration; the syrup is then boiled so as to concentrate it to a point at which it will readily crystallize into white loaf sugar. To ascertain this point was once a difficult and uncertain matter, but now, by the employment of these beads, there is no difficulty in ascertaining the point of concentration at which the process of boiling must be stopped. While the syrup is weak, *i. e.*, while it contains much water, three properly adjusted beads are thrown in, which sink to the bottom. As the water evaporates, the syrup becomes more dense, and one of the beads rises to the surface. This warns the workmen to watch the process, as the syrup is near the strength required; the second bead soon rises, and then all the preparations are completed for drawing off, which is done the instant the third bead rises. The syrup is then placed in conical moulds to crystallize, and comes out in the form in which we see them at the grocer's shop.

Before we quit the subject, we must not omit to mention an elegant mode of determining specific gravities, first devised by M. Say, under the name of the *Stereometer;* and afterwards presented in an improved form by Professor Leslie by the name of the *Coniometer*[*]. The principles on which it depends are perhaps more philosophical than those of any other hydrometer. Its object is to determine the specific gravities of porous bodies, soft substances, and powders. If we take in the hand a piece of granite and a piece of Vesuvian pumice-stone, we directly say that the granite is much heavier, bulk for bulk, than the pumice-stone; but we must not forget that the pumice is full of cavities, and pores traversing it in every direction, and that we have obtained no information as to the absolute quantity of solid matter which it contains. This latter problem cannot be solved by the other hydrometers or hydrostatic balances; but Leslie's instrument measures the solid matter of such bodies with singular elegance.

Fig. 10.



A E is a glass tube about three feet long, two-fifths of an inch in diameter at the upper part, A B, and one-fifth at the lower part, B E; at B the tube is closed except a very small slit, too small to admit anything but air; the top, A, is ground smooth, to admit a glass plate being placed air-tight upon it; M is a glass vessel nearly full of mercury.

The powder, or porous substance, is put into A B, where it rests at B; the tube is then put into the vessel M until the mercury rises to B. The glass cover is then put on the top A, and thus the communication with the atmosphere is cut off both above and below. The part A B therefore contains the powder, and a certain, but unknown, quantity of air. The tube is then lifted up, until the mercury stands in it at half the height indicated by a common barometer at the time. Say that the latter is at thirty inches; thus the tube is to be elevated until only fifteen inches of mercury remain above the level of the mercury in M; but in proportion as the mercurial pressure diminishes, the air in A B will expand; that air was of the ordinary pressure (or thirty inches) when the plate was laid on the top, and therefore when the pressure from below is diminished from thirty to fifteen inches, the air expands to double its former bulk, and insinuates itself through the small fissure into the tube B E; we will suppose that the line of division between the mercury and air is now at C, then we may feel quite sure that the quantity of air in A B is precisely equal to that in B C, because the air is just half its former density. The tube is then emptied, and again thrust into the vessel of mercury, and the plate put on, while the part A B contains nothing but air. It is then elevated as before until the mercury stands at fifteen inches in the tube; but in this case the air occupies a larger space than before, it reaches down say to D, because there was more air to undergo the process of expansion than in the former case. Now a little reflection will show that the space C D is exactly equal to the actual bulk of solid matter in the powder originally introduced into the instrument; because, as B C was exactly equal to the space occupied by air in A B when the powder was present, and as B D is exactly equal to the whole space A B, it follows that the space C D is equal to the solid matter of the powder or porous substance. The weight of a quantity of pure water equal to the space C D, having been ascertained, and likewise the weight of the powder in air, the specific gravity of the solid matter of the powder can be determined in the manner before detailed.

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[*] From κονις, *dust*, or powder.

ON TIME-KEEPERS.

II.

WATCHES AND CHRONOMETERS, OR PORTABLE TIME-KEEPERS.

IT is obvious that a clock with a pendulum and weight can never be a *portable* machine; and since it is necessary that the clock should be steady, to ensure the correct action of the pendulum, such a clock would be useless on board a ship. But it is precisely on board of vessels making long voyages, that the most accurate *measurers*, or *time-keepers*, as they are called, are required; and it will render the subsequent account of chronometers* more interesting to the reader, if the reason of this necessity is first briefly explained.

When a ship is out of sight of land, as it perpetually must be for many weeks together, it is necessary to ascertain, from time to time, her exact place on the ocean, as laid down on maps and charts, so that her true course may be preserved, to enable her to reach her destination; as well as to keep her clear of sunken rocks, sand-banks, currents, &c.: that is, it is necessary to ascertain frequently her *latitude* and *longitude*.

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* This word is from two Greek ones, meaning *time* and *measure*: it is only applied however, to the best kind of *watches*, or *portable time-keepers*, those used for astronomical purposes.

The *latitude* of any spot on the earth's surface, is its distance from the equator, measured in *degrees*, *minutes*, and *seconds*, on a circle supposed to pass through the place, and through both *poles* of the earth; such a circle is called a *meridian*.

The *longitude* of the same spot is its distance, estimated in degrees, &c., on a circle *parallel* to the equator, and passing through the place in question, and measured from the *meridian* of some important place, as the national observatory; thus the English reckon the longitudes of places from the meridian of Greenwich; the French, from the meridian of Paris, and so on.

Now the latitude of any place, or spot in the ocean, is easily ascertained by direct observation of the sun at the place in question; but means for determining *the longitude*, has been the most perplexing problem that ever occupied the attention of mathematicians and astronomers; and, as far as a *perfect*, or a theoretically-accurate solution is concerned, remains so still; but an *approximation* to the true longitude is attainable by means of chronometers; and the more perfect these instruments, the more accurate that approximation.

All circles are supposed to be divided into 360 degrees, of sixty minutes each, each minute being again subdivided into sixty *seconds*, and so on; and since the earth turns round on its axis, or on the imaginary line passing through the poles, once in twenty-four hours, fifteen of such degrees of the equator, and of every circle parallel to it, must pass under the sun, as a fixed point in the heavens, every hour. That is, if the sun be on the meridian of a place, in one hour afterwards it will be on the meridian of every place fifteen degrees to the west of the first; and so for every other distance, or period of the day, in proportion.

Now the hours of the day are reckoned from the *noon*, or from the precise moment when the sun comes on the meridian of any place; and this moment can be determined by observation on board a ship, at all times. If, therefore, there is in the vessel a chronometer which shows the time at Greenwich, having been set to the time there when the vessel set sail on her voyage, the difference between the time indicated by that chronometer and the true time on board at the moment, will furnish the data for determining the longitude*.

Hence the necessity for constructing chronometers that will keep time to a second, for long periods together; for since four *minutes* in time are equivalent to a *degree* of longitude, an error in the chronometer on board, of half a minute, or thirty seconds, would give the longitude wrong by *eight miles*, no trifle to a vessel looking out for port in foggy weather, or when endeavouring to avoid a sunken rock or a sand-bank. Accordingly, to such perfection are these invaluable instruments brought, that, under favourable circumstances, the longitude can be determined by means of them to nearly a mile; and it is not uncommon for a fine chronometer to have been carried to India and back again, without having erred more than half a second.

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* It must be observed, that the real process for this purpose is much more complicated than might be inferred from this statement, but it is put in this simplified form to render the principle intelligible to the general reader.

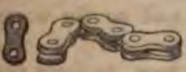
We shall begin our description of *portable* time-keepers with that of the substitute for the *weight* of the clock; or the *moving power* that is employed in portable time-keepers.

A long thin slip of highly-tempered steel is coiled round in a spiral, and put into a cylindrical box; one end of the slip is attached to a central axle, round which the box can turn, while the other, or outer end, is fixed to the box itself. If the box be turned round and round, so as to increase the number of coils of the spiral within it, the *elasticity* of the steel, exerting itself to recover its former relaxed state, causes the spring to turn the box round back again, and thus becomes a moving power, capable of setting a train of wheels in motion. This steel slip is called the Main Spring.

The central axis, to which one end of the main spring is fixed, has a small ratchet-wheel and click at one end, out of the box, by means of which the *tension* of the spring can be regulated, or increased when it becomes weak by age; the ratchet allowing the axle to be turned round in one direction only for this purpose.

The time-keeper must have a separate main spring for each *movement;* or one for each *weight* it would require if it were a clock of the ordinary construction: thus a portable time-keeper which struck the hours would have two main springs; and the ratchet-wheels for allowing the regulation of the tension of two such springs are seen at A, B, in the figure, page 381, which represents such a clock.

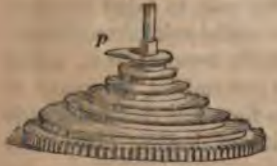
Fig. 12.



The action of the main spring is communicated to the wheel-work by means of a fine steel chain, of peculiar construction, made of small links as shown in the figure: each link consists of two equal pieces placed over each other, and they are connected by another piece, of precisely the same form and size, placed between the two constituting the link; a rivet passing through the three, so that every link has two rivets in it. By this construction, the chain is rendered flexible in one *plane* only, and not in all directions, as common chains are.

One end of this chain is hooked by a small hook to the box of the main spring, the other end is attached in a similar manner to what is called the fusee, which, from the beautiful simplicity of its principle, as well as from its importance in the watch, must be described at some length.

Fig. 13



The general form of the *fusee* is seen in the figure; its surface is cut into a spiral flat groove, wide enough to admit the steel chain, and deep enough to prevent this from slipping out of it; the chain is hooked to the lowest coil of the groove, and a *key* being applied on the squared end of the arbor, the fusee is by that means turned round and round till the chain is wound on to it, and fills all the groove from the bottom to the top: this motion turns the box of the main spring round and round, and therefore braces up the spring, so as to cause it to exert its greatest force of recoil or of elasticity.

The fusee is provided with a ratchet-wheel beneath it, to admit of its being wound up, and to prevent its being turned back again by the tension of the spring, in precisely the same manner as the ratchet of a clock acts on the barrel (*see* page 373), the fusee answering to the barrel, or pulley of the clock, and being, like these, fixed to the first wheel of the train.

The main spring exerts its greatest force when first wound up, and this force gradually diminishes as the spring uncoils; when, therefore, the watch is nearly *down*, and all the chain nearly wound back again off the fusee on to the box, the train would be turned slower and slower as the spring gradually lost its power; the object of the fusee is to remedy this progressive diminution in strength of the spring.

The spiral form of the groove causes the chain, when the spring is exerting its greatest force, to pull the fusee round from a point nearest to its axis. The imaginary straight line, from this point, where the chain quits the groove, to the axis of the fusee, is a *lever*, which this spiral groove causes to lengthen gradually, as the spring diminishes in force; and from the well-known principle of that mechanical power, as this lever lengthens, a diminishing force applied at one end will produce a constant effect, or overcome a constant resistance, at the other end of the lever. So that the fusee will always move round with the same constant velocity, though turned by the gradually relaxing effort of the spring.

To make the adjustment of this action *true*, the outline, or *profile*, of the fusee must not be *conical*, for if it were, the lever above alluded to would lengthen *equally* after *equal* portions of motion in the fusee; but it is found that the elasticity of the spring does not diminish in an *equal*, or constant, proportion; and to counteract this inequality in the ratio of the diminishing power, the lever must lengthen in a certain increasing ratio, which is effected by making the general profile of the fusee a peculiar curve. This is ascertained by general theory, but each fusee should be adjusted so as to produce the desired effect, or so that the train of wheels may at all times move with the same velocity.

Fig. 14.

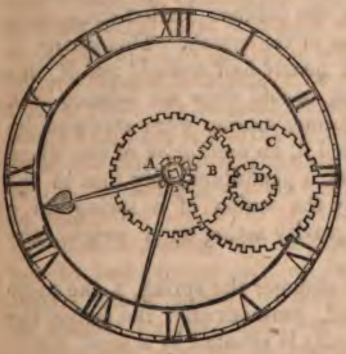
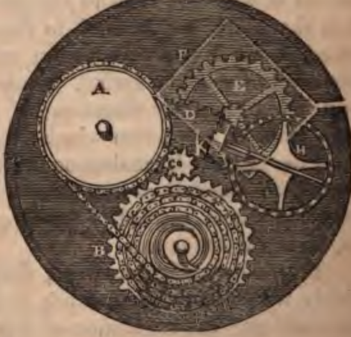


Fig. 15.



In chronometers, or time-keepers required to go accurately, the fusee has a second ratchet and spring, as before described (page 384), to admit of the machine going while it is being wound up; and each main spring must have its fusee to regulate its action: thus, for example, the clock (fig. 8, p. 381) has two, A B being their arbors, one spring acting on the *going* part, the other on the striking part.

The preceding figures show the number and arrangement of the wheels in a common watch; these wheels are kept in their places on and between two circular plates, fixed at the requisite distance from each other by small pillars, in a manner analogous to the frame of a clock, and therefore not requiring further description; in figure 15, one of these plates is supposed to be removed, for the purpose of showing the wheels which lie between them.

A is the box containing the main spring, B the fusee, on the arbor of which is placed the first wheel of the train, acting on a pinion and wheel, C, which again move a pinion and wheel, D, and D turns a pinion on the arbor of a wheel E, which turns the *contrate* wheel, H, having its teeth perpendicular to the plane of the rim, which disposition admits of their working in the horizontal pinion on the arbor of the small *crown*, or *escapement*, wheel, which effects in the watch the same purpose as in the clock, namely, that of retarding the motion communicated to the train by the main spring, so that it may continue for a longer period.

We must now explain the substitute for the pendulum, or the regulating part of the movement, in a watch. This consists of two essential parts (*see* fig. 16). First, a wheel F, called the *balance*, which has a plain circular rim of steel, with three light spokes, the principal mass or weight, therefore, lying in the rim: an analogous wheel is employed in most machines, under the name of a *fly-wheel;* because in such machines this wheel, being made to revolve with great rapidity, becomes, in consequence of its weight and size, a reservoir, as it were, of *power*, which will enable the wheel-work to continue moving for some time, if the original moving power be stopped, and also equalizes the velocity of the motion in all circumstances: it is in this latter manner that the balance acts in a watch, though on a different principle, and thus corresponds to the *bob* of the pendulum of a clock.

The second essential part consists of a very fine steel spiral spring, S, one end of which is fixed to the arbor of the balance (called the *verge*), while the other end is fixed to the frame of the watch. This spring is *braced up* by the balance, when turned nearly half round, and if this were left to itself, the spring, by uncoiling, would draw the balance back again in the contrary direction; if the former motion were renewed by a repetition of the action which occasioned it, an *oscillation* of the wheel would be produced, analogous to that of a pendulum, only that in the former the oscillations are produced by the action of a spring on a horizontal wheel, instead of the force of gravity acting on a weight, the bob, as in the latter case.

It will be easily perceived, that the stronger the spring, S, the more quickly will it draw the balance back, and, consequently, the faster the watch will go; the regulation of this velocity is effected by a small circle, lying on the upper face of the frame plate, and turned in either direction by a key applied on the end of its arbor; a pinion on this arbor acts in the teeth cut on the outer edge of a small arc of metal, called the *curb;*

which is placed *concentric** with the balance, but below it. The curb carries at one end a pin, which presses against the spiral spring, s; and by moving this pin in opposite directions, the spring is, in effect, lengthened or shortened so as to cause it to act with less or greater force, and consequently to turn the balance slower or quicker.

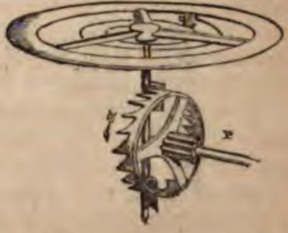
The small circle has figures engraved on it, to indicate the direction in which it must be turned by the key so as to cause the curb-pin to act on the spring to produce the required change in the rate of the going of the watch.

In order to render the oscillations of the balance capable of *measuring time*, they must be equal in extent, and equal in velocity, or the balance must turn round always an equal portion of the circumference of the circle of its rim, and with an equal rapidity. When these conditions are fulfilled, the oscillations, for reasons before given, are concluded to be performed in equal portions of time, or are *isochronal*, as it is termed. The *isochronism* of the oscillations of the pendulum depends on the distance between the point from which it hangs, or round which, as a centre, it turns, and the centre of the weight or bob, being always the same; for, since the escapement causes the arc of vibration to be always of the same length, and since the weight of the pendulum remains always the same, if the length be kept constant, the conditions necessary to isochronism are fulfilled, according to the theory of mechanics. But in the case of a watch, or chronometer, instead of a constant, unvarying power, like that of gravity, there is a slender wire spring, which becomes weaker from use, and which cannot be made equally strong in every part, from the imperfection attending all human works: this spring, therefore, besides those adjustments which are common both to the balance and the pendulûm, or are analogous in their effects, being intended to counteract the effects of changes of temperature, requires an appropriate one of its own to remedy its imperfect construction.

Before proceeding to explain the mode of applying the adjustments to the balance of a watch, and to describe the various kinds of escapements which have been invented with the intention of obviating these deficiencies, we shall conclude our account of the wheel-work of a common watch; for these adjustments are not applied in this, while its wheel-work differs but little from that of a perfect chronometer.

The *verge*, or arbor of the balance, has two pallets, which stand out from it in different directions, so as to be acted on alternately by the sloping teeth, in the opposite sides of the crown escapement-wheel, in an analogous manner to that before explained (p. 375), when the escapement of the clock was described.

Fig. 16.



These parts are so arranged, that when the watch is not going, the balance-spring is at rest, that is, exerts no force to turn the balance either way: if we now suppose the train to be set in motion, the crown escapement-wheel turns in the direction shown by the arrow; the uppermost tooth presses against the pallet, and carrying it before it, causes the balance to turn from left to right, and by so doing, winds, or braces up the spring; but when the pallet is turned so far round as to suffer the tooth to *escape* from it, the balance has acquired a power of motion, called in mechanics a *momentum*, which carries it on further, till the increasing tension of the spring counterbalances it, and stops the oscillation in that direction. By this motion, the lowermost pallet is brought round against a tooth, which, by the continued motion of the wheel, was advancing to meet it, and send it back the other way; the collision is sufficient to force back the wheel a small quantity, and thus causes that jerking motion of the second-hand of common watches having ordinary escapements; to remove this defect is the object of the *dead-beat* escapement hereafter described. When the tension of the balance-spring becomes sufficient to counteract the momentum of the balance, this would begin to oscillate in the contrary direction by the force of the spring alone, but it also receives an additional impulse from the tooth, which now urges the lower pallet before it; and the balance turns from right to left, through an arc of a circle equal to that it first moved in, in the contrary direction; the spring being unwound as much as it was before braced up, but this unwinding being equally opposed to its quiescent state, its elasticity soon causes the spring to counteract the momentum acquired by the balance in that direction, and to overcome it; the recoiling action is again renewed on the upper tooth, which has been now brought to act on the pallet; and so on alternately.

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* Two circles, or arcs of circles, are said to be *concentric* when they have a common centre, or when their centres lie in a line perpendicular to their planes.

The balance and its spring lie on the outside of the frame-plates, the one extremity of the verge being held by a raised *cock*, screwed on the outer face of the plate; in common watches this cock is made of a circular form, in order to protect the balance by covering it, and is cut into open filagree work, through the interstices of which the spring may be seen in action. The socket of the verge in this cock is generally made in a ruby or diamond, let in for that purpose, for the reason now to be explained. When steel pivots work in brass sockets, they in time wear out, and the arbor thus becoming loose and unsteady, the action is deranged. It was to remedy this evil that a Swiss watch-maker of the name of Facio, in 1700, inserted a jewel in the fixed supports, to receive the pivots of the arbors of all the principal wheels; the hardness of these stones not only prevented their wearing by action, but also by diminishing the constant friction, materially improved the going of the train, and caused the pivots to last longer; in common watches the verge only has a jewel for its socket.

The lower end of the verge is carried by another smaller cock, screwed on the under side of the same plate, and which also receives the one end of the arbor of the escapement-wheel; a third little cock, in a similar situation, receives the other end of this horizontal arbor.

A small pin is fixed on the rim of the balance, which is stopped against projections in the circular cock above mentioned, when any sudden jerk, tending to cause the balance to oscillate too far, would endanger the spring by over-straining it but for this contrivance, which is called *banking:* and the straining of the spring would not be the only mischief arising from such an irregular vibration, for the pallets might be turned so far by it, as to free them entirely from the teeth of the crown-wheel, which, with the rest of the train, being thus left to the uncontrolled action of the main spring, the watch would run down, to the great injury of the teeth and the works generally.

The remaining part of the works of a common watch consist of two wheels, with a pinion on the arbor of each, and are placed on the outside of the other circular plate, immediately under the dial, so as to be invisible when the whole is put together. The first of these wheels, which are shown in the figure, p. 431, is carried on the arbor of the wheel D, and the second on that of B, which is in the centre of the circular plate; the two arbors of the two last named wheels are concentric, one being within the other, and carry the hour and minute-hand round on the dial, in the same way as was before described of the corresponding part of the clock movement.

The hour-hand, in both machines, being placed on a circular pivot, and retained on it by friction only, allows of that hand being turned round to be set to any hour, without turning the wheels, while the minute-hand, being fixed on a square arbor, if that hand be turned, it will cause all the train to turn, and consequently will also move the other.

There remains yet another contrivance to be noticed, the object of which is to prevent the main-spring from being broken or overstrained, or the same accidents happening to the chain, by turning the fusee too often round when the clock is being wound up: this is accomplished by means of a slight spring fastened to the upper plate, and lying across the direction of the part of the chain between the main-spring box and the fusee; when the chain is wound on to the upper groove of the fusee, it raises this spring, and that again raises a lever to the level of the cap on the fusee, which is made with a projecting piece, *p*, to strike against the lever, and thereby to prevent the fusee from being turned further: every one, in winding up a watch, feels the obstruction to turning the key round more than the proper number of times, caused by this lever.

The balance and its spring are affected by change of temperature, and this would derange the velocity of the train in the same manner as changes in the length of the pendulum affect the going of a clock.

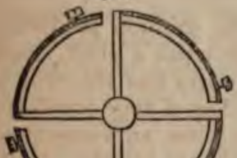
If the spring, from changes of temperature, becomes longer or shorter, it acts more or less strongly on the balance, causing it to oscillate faster or slower. This source of derangement is usually guarded against in chronometers, by means of what is called a *compensation curb:* this is of various forms and constructions, all founded on the unequal expansion or contraction of two metals exposed to the same temperature.

If an arm or arc be composed of two equal pieces of brass and steel, riveted together, the greater expansion of the one metal, when the temperature is raised, will cause the arm, if it were straight, to warp or bend, or the arc to assume a greater or less degree of curvature: by these changes of form, the pin carried on such a compound arm would press against the spring at different points, according to alterations in the temperature to which the chronometer was exposed; and, by experiment and theory, the arm can be constructed so as always to produce the proper action on the spring.

The balance, also, is altered in its diameter by changes of temperature, expanding or contracting the rim and spokes: now, although the whole *weight* of the balance is not altered by these changes, yet, since the principal portion of that weight is in the rim, this portion, by being removed farther from, or nearer to, the verge, or axis of oscillation, diminishes or increases the momentum and velocity, and thereby affects the rate of going.

The *compensating balance*, to correct these variations, is usually made with a rim in equal portions, each carried by a spoke, and unconnected with each other, though forming a circle. Each piece is formed of two concentric pieces of steel and brass, riveted together, and at the extremity of each arc there is a small, though comparatively heavy, weight attached, in some mode, which, by the unequal contraction of the metals causing the compound piece to warp, is brought nearer to, or farther from, the axis of motion, and thereby compensates for the contraction or expansion of the spokes and rim generally. The weight on the compound arcs above mentioned is generally either a small screw with a large solid head, or is made to slide on the rim, and thus admit of adjustment to produce the proper effect.

Fig. 17.



There are also small screws at the ends of the spokes, for the purpose of adjusting the balance *for time*, on the same principle that a pendulum is adjusted originally to its proper length, independently of its compensations. Thus, for example, if it were found that at ordinary temperatures the diameter of the rim of the balance were too small, so that it oscillated too quickly, by screwing out these timing screws a little, the general weight is removed a little farther from the axis, producing thereby the same effect as if the real diameter of the rim were increased.

It is also essential to the correct action of a balance, that its rim should always oscillate in the same plane; and this requires that the plane of that rim should be truly perpendicular to the verge, and that the rim should be equal in every part, and truly circular: the derangements arising from defects in these respects, are also remedied by small screws in the rim, these adjustments being analogous to those by which the pendulum of a clock is put into true beat (*see* p. 387).

All metals being greatly affected by changes of temperature, compensation balances are requisite in chronometers, whatsoever metal these balances may be made of; but it has been ascertained, that the oscillations of a steel balance are deranged, in some inexplicable manner, by the magnetic fluid constantly circulating in the atmosphere, and this action was greatest on board of ships: to remedy this source of error, the balance has been made of gold, as not being subject to magnetic influence, and as being heavier than steel, and less liable to rust from the atmospheric action. An eminent chronometer-maker has recently established a series of trials with balances, and even the springs, made of glass, as not only combining the advantages of gold, but also as being less affected by temperature than any metal; but it has been found that the elasticity of glass is not so permanent as that of steel, and it is to be feared that the attempt to use that substance, for the springs at least, must be abandoned: this comparative failure is the more to be regretted, as experience had shown that so apparently fragile a thing as a glass spring, was not more liable to be broken by ordinary casualties, than if if were made of steel.

In all machinery, it is necessary to apply oil, or some greasy matter, to the parts that work together, to prevent them, by diminishing their friction, from rapidly wearing away. In a machine so delicate as a chronometer, not only must the least quantity of oil that will suffice be used for this purpose, but only peculiar oils can be employed, such as do not easily decompose and act on the metals, and such as do not thicken soon by exposure to air. These oils must not only be well washed, to free them from foreign matter, but chemical processes must be employed to free them from any acid in them which would corrode the pivots and sockets. Oil of Ben, prepared from the seeds of the *Moringa geylandica*, a plant a native of Egypt and the East, has been found to answer the best for the purpose.

It is said that Harrison, the inventor of the gridiron pendulum, having once been sent for from a great distance to repair a clock, found that the principal source of derangement in the works was the want of fresh oil and a little cleaning; reflecting on the loss of time occasioned by this circumstance, he contrived, on his way home, an escapement, which should not require any oil to be applied to the pallets. It did not, however, succeed, and it is still necessary to touch the pallets with a drop in all clocks and time-keepers.

The minute portion of oil applied to the pivots of the verge, has been made to serve as a kind of *compensation* for changes of temperature; when the balance by contraction from cold increases its velocity, the thickening of the oil from the same cause acts in retarding the motion, and the reverse in warm weather. It is almost needless to add, that this contrivance is too uncertain to be relied on, and that it is more ingenious in principle than useful in practice.

ESCAPEMENTS.

IT has been shown that both in the watch, or portable time-keeper, as well as in the clock with a weight and pendulum, the escapement is the contrivance by means of which the *alternating motion*, or oscillations, of the *regulating* power communicates with and governs the *continuous motion* of the *maintaining* power; and in return, by means of the escapement, the maintaining power imparts a new impulse to the former, at each of its oscillations, to supply that force which would otherwise be continually diminishing, and soon stop, in consequence of friction and resistance of the air.

Hence the importance of the escapement in these machines is obvious, and the necessity for its being as perfect as is practicable, both in principle and execution. The constant endeavour to attain this perfection has given rise to a great variety of different escapements, the principal of which we shall now proceed to explain.

In this account of the principles and construction of various escapements, we shall *not* distinguish those used in clocks from those employed in watches, because, in *principle*, the two machines are alike, and any escapement is therefore equally applicable to both. We shall consequently class them according to the particular object which each kind is intended to accomplish.

It must be remembered that by the *maintaining power*, is meant the *weight* of the clock, or the main-spring of a watch; that power by means of which the wheel-work is kept in motion: and by the *regulating power*, the pendulum of the former, and the balance and its spring in the latter machine, is implied. Escapements are divided into four classes.

1.—Recoil Escapements.—The common crown-wheel escapement, which has been already described, is the oldest of these, and may be considered as their *type*, as it is indeed of all others. The name is derived from the circumstance of the *momentum*, acquired by the regulating power at each oscillation, carrying the pallets on so far as to cause them to re-act on the teeth of the escapement-wheel, forcing this back, or causing it to *recoil*, before the oscillation in the contrary direction begins. These escapements may be recognised by the confused *ticking* of the time-piece which contains them, very unlike the clear simple sound produced by other escapements. This *recoil* of the escapement-wheel is thought to interfere with the correct action of the train, and to injure the teeth of the wheels; added to which, in astronomical clocks, precision in the beat, and distinct steady motion of the second-hand, are absolutely necessary, to allow of the seconds being correctly counted during observations: accordingly, in order to remedy these defects, Tompion, a celebrated horologist, invented, in 1695, the

2. Dead-beat Escapement, which, variously modified, has been since used in all clocks and watches of the better construction. That before described in p. 375, is a dead-beat escapement, and was an improvement by Graham on the older form called the *Crown and Anchor Escapement*, which is shown in the upper part of the figure accompanying that description; by referring to that figure the improvement will be easily understood. In the old form, in consequence of the vibration of the pendulum not being quite completed at the moment the tooth struck the pallet, the inclined face of this, acting as a wedge, forced the wheel back by pressing against the tooth. Graham cut away the angle of the pallet, reducing it to the form shown in the lower figure, and thus allowed the plain face of the pallet to slide on that of the tooth without causing any backward motion in the wheel, as was before explained, or the tooth was *dead* and motionless for the time it was at rest; hence the name.

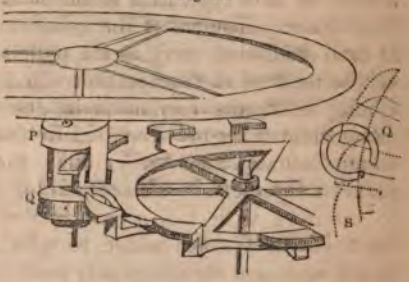
It must be now mentioned, that it is only for an indefinitely small space that the plain part of the pallet slides on the front of the tooth, the object being gained if there be no recoil in consequence of the tooth not being at all forced backwards; while it is important that there should be no unnecessary friction on these parts, which tends of course to alter their form by wearing. If the obtuse angle of the pallet which first receives the tooth were much rubbed away by such friction, the quantity and direction of the force employëd to restore the loss of motion in the pendulum, would vary; and this would affect the arc of vibration, and consequently derange the whole machine.

In most good escapements, for this reason, the part of the pallet against which the teeth of the wheel strike, or slide, is made of agate, ruby, sapphire or diamond, to obviate wearing as much as possible, while a little alteration in the shape of the teeth themselves is not of so much importance, since all of them must necessarily be changed alike, each being subjected to exactly the same force and friction.

By applying geometrical principles for finding the distance of the axis of the anchor from that of the escapement-wheel, and for finding the length of the arc of the former, Graham improved on the old form as much in the principle of its motion as in the practical details of form.

The same able artist was also the inventor of a beautiful dead-beat escapement for watches, which is still much used. In the annexed figure, only a portion of the balance wheel is shown, but all the other teeth are precisely the same in their peculiar form, which will be better understood from the figure, than from any description. P is a hollow cylindrical pallet, half of which is cut away, and which turns on the vertical verge of the balance; in the detached figure, the *plans* of this, and that of one tooth are shown in another position, and the following description refers to both figures.

Fig. 18.



Although P is in one piece, the two edges of the hollow part serve as distinct pallets, inasmuch as they receive alternately, during each oscillation of the balance, an impulse from the curved outer edge of each tooth in succession. When the oscillation has turned C round, the tooth S strikes on the outer or convex part; and since this is concentric* with the axis of rotation, the pallet slides against the point of the tooth without causing any recoil, that is, the beat is *dead*. When by turning back again, the edge P of the hollowed part passes the point of the tooth S, the escapement-wheel again moves on, from the action of the maintaining power, and the curved edge of the tooth in passing presses against P like a wedge, thus imparting the restoring impulse to the balance. The oscillation, by continuing, carries P out of the influence of this curve, and the tooth proceeds till it again strikes *dead* against the inside concave face of the cylinder, which slides against the point without causing any recoil for the same reason above mentioned, this inside face having been brought round to receive the tooth by the motion of the balance.

When the oscillation in that direction is completed, and the return one begins, the edge Q is soon removed from holding the tooth; and as this passes on again, its edge, as before, imparts an impulse to Q, till this is removed from its influence, and a new tooth is caught again on the outer face of the pallet as before, and so on in succession. The size and form of the pallet and teeth are calculated so that the former can inclose the latter without touching it in any other part than at the point of the tooth, while this is being held against the inner surface; for otherwise the oscillation would be stopped by the first edge of the pallet striking against the tooth when in that position.

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* See note, p. 433.

Thus each tooth, before it finally quits the pallet, is twice stopped dead by it, and imparts an impulse to the balance in the two directions in which it alternately moves, one each time it passes an edge of the pallet.

All the numerous dead-beat escapements since invented or employed, are but modifications and practical improvements on these two. One, however, the *Duplex escapement*, must be described from its frequent occurrence, and from the peculiarity of its construction. This consists in the pallet being double, and in the escapement-wheel, which has a second set of teeth on its upper face, intermediate to those projecting from its rim. The pallet is a cylinder, with a notch cut in it, acting on the teeth last mentioned, in the same manner as in Graham's, as regards their being stopped dead on the outer surface of the cylinder; but, instead of being next caught by the notch, this allows them to pass clear of the pallet, while a second one, of ruby, attached to the verge, catches the intermediate contrate tooth; and on the return oscillation, this pallet overtakes the tooth in advance, and imparts the restoring impulse.

THE motions of a pendulum swinging freely, or of a spring alternately expanding and contracting, are made according to *natural* laws, under the influence of incorporeal agents, namely, gravity and elasticity. These motions are, consequently, not only different in kind, but far more constant, equal, and regular, than any which could be imparted to these bodies thus actuated by means of machinery, imperfect at best, of human construction.

For though this machinery, of course, equally obeys natural laws, yet its unavoidable imperfections are perpetually altering and deranging the motions transmitted by means of it; and moreover, the species of motion transmitted by wheel-work, as in a clock, is of a different kind to that of a pendulum or spring oscillating freely.

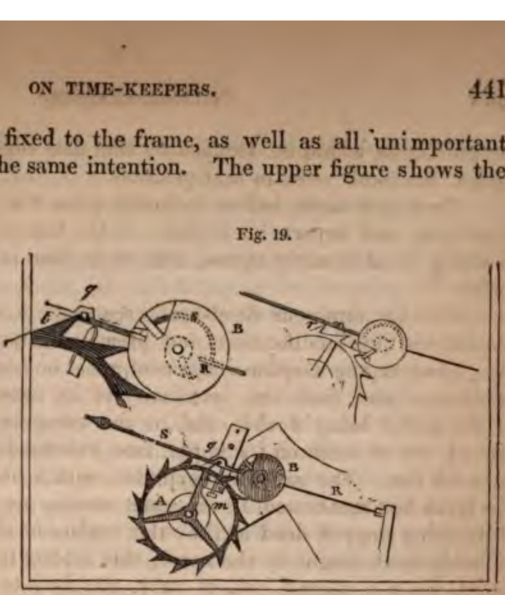
Thus the action of the maintaining power, when transmitted through the forked lever to the pendulum (see p. 375), produces a motion in this, differing from that which the same pendulum would possess if it were unimpeded, and therefore acts disadvantageously on the uniformity of that motion. The same remark applies to the effect of the escapement-wheel on the balance and spring of a chronometer.

Hence, as *uniform motion* is the desideratum in all time-keepers, mechanists have exerted their invention to contrive escapements which should interfere as little as possible with the natural motion of the regulating power: this is effected by causing the escapement to communicate the restoring impulse by a momentary touch, which, being again instantly suspended, may leave the balance or pendulum to oscillate freely without impediment: these contrivances are named

3. THE DETACHED ESCAPEMENT.—The first was invented by Peter Le Roy, a French watch-maker, in 1748; we can only describe two, which will show the general principles on which they are all constructed.

The annexed figures are *plans* of such an escapement in two different positions, which will explain the action better than an ordinary view; and the cocks by which it is fixed to the frame, as well as all unimportant parts, are omitted with the same intention. The upper figure shows the parts when at rest.

Fig. 19.



A is the escapement-wheel, B the pallet, on the verge of the balance; this pallet is a circle of polished steel, with a notch cut out of it, into one side of which a polished flat piece of diamond is inserted for the acting part: below this steel pallet, but carried on the same verge, is a small piece of steel having a sapphire fixed to it for the acting part; the shape of this pallet is indicated by a dotted line. S is a long slender spring, having its end curved into a semicircle, to keep it clear of the verge; this end is shown in dotted lines in the separate figure, because it lies under, and therefore is hid by B. *q* is a projection in the spring, carrying a small upright pin, called the *locking pallet*. R is another slender spring in the same line with S, which line, when the springs are at rest, would pass through the centre of the verge. *m* is a small screw, against the point of which the spring S strikes, and thus prevents it from springing too far back: the action of these parts is as follows:—

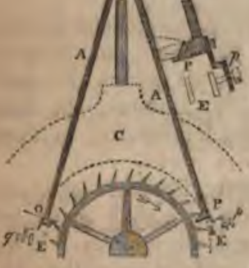
When at rest, the circular edge of B is just clear of the two teeth of the wheel which are nearest to B, but yet, if set in motion, the tooth could not pass B: in this position, both S and R being quiescent, S rests against the screw *m*, and the tooth *t* resting against the locking pallet *q*, the escapement-wheel cannot turn. To set the chronometer going, it is necessary to give it a sudden turn round, which sets the balance oscillating; this causes the lower piece on the verge, called the *lifting pallet*, to strike against the end of the spring R, which, from its overlapping S, pushes S back, and thus removes the pin *p* from before the tooth of the wheel, or *unlocks* the escapement-wheel, and this is immediately moved on by the maintaining power. The same oscillation given to the balance and verge, brings the diamond pallet B round before the tooth *t*, which strikes against it, and carries it round as far as is shown in the upper figure, in which the tooth is shown just quitting the pallet: the recoil of the spring S has now brought the locking pin *p* to catch the tooth *r*, and the escapement-wheel is again stopped. But the stroke of the tooth *t* on the great pallet has given a sufficient impulse to carry the balance on in its oscillation, till it is counteracted by the tension of the balance-spring, which brings it back again in this return oscillation; the lifting pallet, by its curved back, pushes the slender spring R before it, and passes it without affecting S, which is stiff enough to remain unmoved by R, even when *this strikes and rests* against it in recoiling: the wheel, therefore, continues locked, and the oscillation proceeds uncontrolled till the great pallet is again brought round more than a complete turn, and the balance-spring again checks the oscillation, the above process being repeated.

In this escapement, consequently, part of one oscillation, in one direction, and the whole of that in the other, is performed without the balance being in any way under the influence of the maintaining power; while the parts are so contrived that the impulse given by this power, by means of the stroke of the tooth on the great pallet, is calculated to affect as little as possible the natural motion of the balance.

The principal mechanical feature to be remarked and understood is, that the *lifting pallet* can pass the spring R in one direction, without moving S; while, in the other, it carries R, and therefore S also, before it. In this escapement, one tooth only escapes every alternate vibration.

When the detached escapement is applied to a clock, the fork, which, in ordinary cases communicates the restoring impulse to the pendulum, is altogether done away with, so that this vibrates without impediment. We shall describe such an escapement, applied to an astronomical clock*.

Fig. 20.



A A are two thin bars, each fixed to, and suspended by a piece of watch-spring at *n*, and having their pallets, P Q, at their other extremity. These pallets have a small tooth projecting at the bottom of their sloping faces, which act as detents to lock the swing-wheel: these detents, and the acting faces of the pallets, are made of ruby (they are shown larger in the detached figure). One tooth of the escapement-wheel is shown as stopped by the detent of the pallet Q, and the opposite tooth as resting on the inner angle of the sloping face of P. The upper part of the pendulum rod C, is a frame consisting of two flat rings, kept together at a sufficient distance by short pillars; the swing-wheel, pallets, &c., lie between these rings: E E are two flat bars, also fixed across between them.

The pendulum is supposed to be moving from right to left, and not yet arrived at the end of its oscillation; the left-hand bar, E, is beginning to press against the point of the small screw, *q*, which is carried by the pallet Q: hence, when the pendulum has advanced a little further, Q is pressed away from the wheel, and leaves this free to turn on, till the other tooth, sliding over the sloping face of P, is caught by the detent of that pallet, and again stops the wheel: this action forces the bar A outwards a little, and consequently braces the spring by which it is hung at *n*, while that of the other bar being also braced by the motion which freed the pallet Q from the tooth, it begins to react on the pendulum, in consequence of the screw *q* pressing on the bar E: this constitutes the restoring impulse.

As soon as Q returns so as to bring the pallet against a new tooth, A is stopped in its recoil, and the pendulum proceeds in its return oscillation, *free*, or *detached*, till the right-hand bar, E, acts in the same manner as the first, by pressing on the screw *p*, and thereby freeing the pallet P from the tooth which it retained: this action braces still more the spring of the bar A, and prepares it to act on the pendulum when this arrives at the end of the oscillation to the right, and the same process is repeated.

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* The figure and the account are abridged from Mr. T. Read's *Treatise on Clock and Watch-making*.

4. REMONTOIR ESCAPEMENTS constitute the fourth class, and derive their name* from the regulating power having a contrivance to wind up a small weight, or brace up a spring, which may equalize the action of that power on the pendulum or balance.

The balance-spring, when acting on the balance, exerts a varying force, the *elasticity* being greatest at each end of the oscillations, in consequence of the spring being most braced at those times. Now if part of this superior force were directed to wind up another smaller spring, which should exert its *greatest* power when the principal one was acting with its *least*, the balance might be moved by a nearly constant force.

The mechanical contrivances for attaining this object are very complicated, and to make them effective, require exquisite workmanship, both which rendering them liable to constant derangement, added to doubts as to their theoretical merit, cause this species of escapement to be so little employed, that no further particulars respecting them need be here given.

As the object of these papers has been to give only a general account of the construction of clocks and watches, we shall not mention several modifications of the principal escapements which we have described, though these may still be used; as, for instance, the *lever escapement*, and some others. Those who desire information on these particular points, must consult more comprehensive works.

For a similar reason, added to the necessity for more elaborate figures to elucidate them than can be here given, we shall make but slight mention of repeating watches, alarums, musical watches, &c. &c. There is a great similarity, even in the practical construction of the additional parts requisite to enable a watch to strike the hours and quarters, to those adapted to the same end in clock; only that, since there is not sufficient room in a watch for a bell on which the hammer may strike, a thin flat disc, or ring, of steel is employed instead.

There are two principal *movements* employed in repeating watches; the first, said to have been invented, or improved, by Tompion, Quare, and others, is known by the name of the French movement, and is analogous in a great degree to the rack and snail striking movement described in page 381. The other was contrived by an Englishman, of the name of Stockten, who worked for Graham, and is known by his name: it is thought to be superior in action to the former.

THE same obscurity exists respecting the date of the first construction of watches, as attends that of clocks: the invention of these portable time-keepers is generally attributed to the Germans; they were certainly common in France before 1544. But these were rude and clumsy machines, the balance being either a wheel or two arms carrying weights, as in Wyk's clock, the inertia of which alone constituted the regulating power. These early watches did not pretend to divide the hour into minutes even, and were as incorrect in their performance, as clumsy in make.

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* The word is from the French verb *remonter*, "to wind up."

The honour of having added the balance-spring, to equalize and control the oscillations of the balance, is disputed between Huygens and our countryman, Dr. Hooke. Since their time, the history of the watch, as well as of the clock, is a chronicle of progressive improvements, made by the intelligent watch-makers of England, France, Switzerland, &c.

At present, the best watches are those manufactured in London and Paris. Brequet, a celebrated maker of the last-named city, has the merit of making the thinnest and smallest watches compatible with accuracy of action: some of these, which are favourite ornaments with ladies and gentlemen of fashion, do not exceed a half-crown piece in diameter, and are not double the thickness of one.

The principal places in this country where watch *movements* are made, are Prescot, in Lancashire, and Coventry. By the movement is understood the frame and its pillars, cocks, and accessory pins, &c., the great wheel and fusee, main-spring, &c.; but not the dial, cases, hands, balance, &c.

Such a movement is the production of twelve different workmen, by whom its various parts are fabricated and roughly put together to send to London. Movements are sold in this state from as low as twenty-one shillings per dozen to 2*l*. 12*s*. 6*d*. each; but the better sort of "Lancashire movements" fetch from seven shillings each, and upwards. Repeating movements sell for from two pounds to four pounds each.

Twenty-one other workmen are required to complete the watch, from the state in which it is furnished by the movement makers.

Having in a former place mentioned two or three of the principal clocks, we shall here subjoin a notice of two remarkable watches. In the Academy of Sciences at St. Petersburg, there is a repeating watch about the size of an egg: in it may be seen the tomb of the Redeemer, covered by a stone, and guarded by sentinels; the angels suddenly appear, the guards prostrate themselves, the stone is removed, the women enter the sepulchre, and the chant of the Greek church on Easter-eve is performed, which concludes the ceremonial.

In 1764, Mr. Arnold presented George the Third with a watch, which weighed only five pennyweights, eight grains.

General Miscellaneous Observations.

In proportion as a machine is complicated, or consists of numerous parts, it is the more necessary that these should be well made and finished, in order that they may work correctly when put together. This requisite perfection of execution is best attained, in all manufactures, by the principle of the *division of labour;* and is carried farther in clock and watch-making than in most others: there are no less than *one hundred and two* different trades employed in making the component parts of a common watch. A brief notice of a few of these is all that need be given here.

The correct working of the wheels depends on the accuracy with which the teeth are cut; this is accomplished by means of a machine, in the following manner:—The wheel, as cast by the founder, or cut out by a turner, is fitted tight on an arbor, which also carries a large circular plate, with numerous concentric circles engraved on it, each divided into the different numbers corresponding to those of the teeth required on clock and watch wheels; these divisions are marked by small holes drilled through the plate. A pin carried by the end of a fixed arm can be dropped into these holes, thus enabling the workman to move the plate round an equal quantity every time, and to keep it steady when moved; thus the wheel to be cut, being carried round on the same arbor, also moves the same proportional part of its circumference. A sharp cutting tool is turned by various contrivances in different machines, with sufficient force to cut or saw out a notch in the edge of the wheel, each time it is moved on the space of a tooth and an intermediate division, as given by the divided circle on the plate. In this way, all the spaces being cut out, the teeth which are left are first filed a little into their proper form at their points, and then finished by causing the wheel to work with another of the same size as that with which it is to act when mounted in the watch; the teeth of both wheels are by this means worn into the right form, so that there may be no *grinding* or unnecessary friction in their action. The wheel is then rubbed on a stone to remove all *bur* raised by these operations, and after being polished bright, it is fitted on its own proper arbor.

The small steel pinions of chronometers, &c, are made in a different manner. Steel wire of the proper size is drawn through successive holes in a *draw-plate*, which are cut so as to *flute* the wire, leaving as many intermediate ridges as the pinion is to have leaves. The workman next cuts this long wire into short pieces of the proper length; these are then turned in a lathe till the wire is reduced in thickness every where, leaving only a small portion in the right place, which forms the pinion, thus projecting out from its plain arbor; it is subsequently smoothed and polished.

To cut the fusee requires another appropriate machine. This is a sort of lathe, the cutting-tool being mounted on a frame, which is moved sideways during the process, in order to give the spiral form to the groove for the chain, and at the same time the cutting-tool is also gradually pushed in nearer to the axle on which the rough fusee is mounted, so as to diminish the successive diameters of the threads in the proper proportion. These two motions, given to the *cutter* in two directions perpendicular to each other, at the same time, are produced in some machines by screws; but the former is in some cases produced by a wedge-shaped frame, which, by descending gradually between the outer frame and a fixed *cheek*, forces the former sideways and horizontally.

The fusee for a chronometer, after being thus cut, is mounted in a frame, with a train moved by the main-spring intended for the piece. A series of observations are made with this temporary time-piece, to ascertain whether the fusee does really equalise the velocity in the train, which would be varied by the unequal tension of the spring. The fusee is taken out, and carefully altered by deepening some parts of the groove in it, and the trials repeated, till the trial-watch is found to keep *correct time*. For ordinary watches, this is not thought necessary. Fusees are cut alike wholesale, and the springs being also made in the same manner, they work, when promiscuously put together in the watches, sufficiently well for common purposes.

The fusee chains are chiefly made by women, and this manufacture is carried on to some extent at Christchurch, on the coast of Hampshire. The links are cut out of an uniform size by a stamp, worked by an engine; another punches out the rivet holes. The rivet wire is drawn and cut of the proper size, and the component parts are then easily put together.

There is nothing that shows more forcibly the additional value which labour may add to the raw material, than the balance-spring of a watch. A pound of the best iron costs about two-pence; a spring, when finished, weighs about fifteen-hundredths of a grain, and is sold at the retail price of two-pence. Fifty thousand such springs can be made out of a pound of iron; consequently the finished spring is of fifty thousand times the value of the raw material of which it is composed.

Let us now open a common watch, and observe the numerous parts of which it consists, and we shall better understand the necessity for this variety of workmen, for this excessive division of labour.

To pass over the outer silver or gold cases, as not essential to the machine, but which must be the result of many distinct and curious operations of turning, polishing, &c. &c., as also the glass, which has to be cut out of a globe, blown of the right diameter; and in the case of what are called *lunette* glasses, this globe must be blown in a *spheroidal* mould, to give it the right form, and one, or, at most, only two glasses can be obtained from each such globe. To pass over these, there is the *dial;* this is made of a piece of thin sheet copper, hammered into the right degree of convexity, turned up at its edges all round, to receive the *enamelling*, drilled in the centre for the arbor of the hands, and cleaned carefully, or the enamel would not adhere. To prepare the raw enamel is a very delicate and troublesome operation, the materials of it being numerous, and all requiring tedious chemical processes to obtain. This raw enamel is ground fine, spread evenly in several layers over the copper mould, and then subjected to intense heat in a furnace, to fuse it, and nothing but consummate skill and patience will ensure success; without this, the enamel either cracks, runs unequally in fusing, cools of a bad or cloudy colour, the copper warps by the heat, which may be either too great or too little, or a speck of dirt may fall on the fusing mass, and spoil the whole process.

But suppose it successful, the dial has now to be painted; let any one look at a watch or clock-face, and he will see what steadiness of hand and sharpness of eye must be required to draw in, with a camel hair pencil, the circles and their divisions, the figures and Roman numerals, with sufficient accuracy, and neatness, on such a convex surface. The dial must again be *fired*, to burn in these characters, and then trimmed at the edges.

To make the hands, either of copper gilt or of blue steel, is neither an easy nor a quick operation; but we must get to the inside, where, besides the wheels, springs, fusee, and parts before described, there are the circular plates to turn, the pivot and screw-holes to be drilled out; the upper one also is embellished with foliage work engraved on it; the pillars which keep them together to turn, the pin-holes to pierce in the pivots, the three or four cocks, of different forms, to make and prepare, and embellish, that over the balance being highly enriched; to say nothing of the numerous delicate screws required to put these parts together, with blued heads, to render them ornamental.

When all these different parts have been made by the various artificers, the watch-maker, as he is still called, has to put them together. To do this requires nicety of hand, strength of sight, and knowledge of the action of the various parts. He keeps a journal of the going of the watch, regulates it, or, if it errs greatly, takes it to pieces again, corrects the deficient parts, and again puts the whole together. When all this is duly considered, what a triumph it appears of human intelligence and activity, to be able to contrive and make a piece of mechanism, not weighing more than half a pound in weight, consisting of as many separate pieces, and made by at least a hundred different persons, having no communication with each other; these pieces formed of two, at least, but more commonly of three or four different metals, with, perhaps, six precious stones let in in different places, to serve as sockets to the pivots of the wheels, some of which revolve from six to three thousand times in the twenty-four hours. All these are put together with such care, that the machine may be carried round the world, and be exposed to every variation of temperature, from twenty or thirty degrees below zero to more than ninety degrees above it, and yet so correct is the chronometer in principle, and so accurate in its construction, that the *second* hand will travel round the circumference of the dial upwards of six hundred thousand times without an error, at the last, of one-six hundredth part of that circle; or, in short, this machine will keep time for upwards of a year without an error of more than one-tenth of a second.

A POPULAR COURSE OF CHEMISTRY.

XIV.

Phosphorus.—Carbon.

Phosphorus may be obtained at a very cheap rate from the "operative chemists," and about half an ounce of it will be sufficient for all the experiments about to be detailed.

It is a solid substance, and is usually sold in the form of small cylindrical sticks, about a quarter of an inch in diameter, and from four to six inches in length. It is very nearly colourless, or, at all events, of an extremely pale buff colour, and semi-transparent. It is highly inflammable, and therefore the chemist from whom you purchase it will place it in a phial filled with water, and you must remember always to keep it thus, for fear of accidents.

At all common temperatures, phosphorus is soft and flexible; this you can prove by bending one of the sticks between the fingers; but you must not handle it very long, for as soon as the water evaporates, it may chance to take fire by the mere heat of the hand. Replace it in the water when you have ascertained its flexibility.

This property is totally lost at lower temperatures, and phosphorus then becomes crystalline and brittle.

If you put a lump of ice into an ale glass full of water, you soon obtain a low temperature, viz., 32° of Fahrenheit's scale; now plunge the stick of phosphorus into this ice-cold water, and let it remain for a short time, and then, upon taking it out, and trying to bend it, you will find that it instantly snaps asunder.

Phosphorus is insoluble in water; its specific gravity is 1·770, so that it is considerably heavier than water, as indeed is evident by the facility with which it sinks through that fluid.

The term phosphorus is derived from two Greek words, viz., *φως*, *light*, and *φερειν*, *to bear:* this term alludes to the singular property which the substance possesses of shining in the dark.

Take a stick of phosphorus, wipe it perfectly dry with a soft linen cloth, using as little friction as possible; then lay it on the table, and you will find that it soon exhales white fumes, having an odour resembling that of garlic; these fumes result from the slow combustion of the phosphorus, and if you darken the room, you will find that the whole stick of phosphorus, and the fumes, shine with a pale blue light, which increases in brightness as the room becomes warmer.

Fix a bit of phosphorus into a quill or portcrayon, and then gently trace letters or words with it on the table, or on a piece of pasteboard; you will find that all the characters shine with the same beautiful light. You must be cautious not to press the phosphorus too strongly against the surface that you write on, because friction will very readily cause it to enter into rapid combustion, and this is attended with considerable risk to the hands. A burn with phosphorus is exceedingly painful, and very difficult to heal.

If any particles of burning phosphorus accidentally fall upon your hands, plunge them instantly into a basin filled with cold water, which will extinguish the flame, and whilst the hands are thus immersed, pick off the particles of phosphorus, and after this is done, the wound requires the usual treatment for a burn.

To prove how easily phosphorus inflames by friction, it is only necessary to take a very small and thin slice of it (which you can cut off the stick with a penknife), press it between the folds of a cloth, or of a piece of blotting-paper, so as to dry it, and then lay it upon the table, or a bit of board, and rub it with a cork rather sharply backwards and forwards once or twice; the friction evolves heat enough to melt and kindle the phosphorus. It enters into rapid combustion, burning with a fine bright yellow flame, and evolving a large quantity of dense white fumes, which are those of *phosphoric acid*, as will presently appear.

A thin slice of phosphorus rubbed between two or three folds of coarse brown paper will soon inflame, but you will remark that its flame does not fire the paper, nor can you light a slip of paper from it; the reason of this appears to be, that the fumes of phosphoric acid envelope the paper, and render it to a great extent incombustible, or fire-proof.

If you burn phosphorus in a confined portion of air, a compound is formed which may be called an *oxide of phosphorus*, and as it is the preparation used in what are termed "phosphoric fire-bottles," I may as well describe the mode of forming it.

Take a small wide-mouthed stoppered bottle, perfectly clean and dry inside; put into it a bit of phosphorus as big as a pea, then heat the end of a piece of iron wire red-hot in the fire, and stir the phosphorus with it as the bottle stands on the table; the phosphorus burns vehemently at first in the air which the bottle contains, but soon ceases, and now you will observe a reddish substance lining the interior of the bottle; this is the *oxide of phosphorus*. Let the bottle cool, and then insert the stopper. Now, when you require a light, open the bottle and insert the tip of a brimstone match, so as to cause a little of the oxide to stick to it, remove it quickly, and it inflames almost instantly, or will do so if slightly rubbed on a cork. This fire-bottle will last for a long time, and when its action becomes imperfect, it may be restored by stirring the contents of the bottle with the heated wire, adding a little bit more phosphorus if necessary. I need scarcely tell you, that the stopper of the bottle must be inserted each time after procuring a light.

The oxide of phosphorus is of very little interest or importance, and its composition is by no means accurately determined; we will therefore leave it, and pass on to the most important *acid* compound which phosphorus forms with oxygen, viz., *phosphoric acid*, and it is the white smoke so abundantly evolved whenever phosphorus is burned in atmospheric air or in oxygen. This smoke may be condensed and collected as follows:—

A bit of phosphorus, the size of a pea, is to be wiped perfectly dry, and placed in the centre of a clean and dry earthenware plate, touch it with a heated wire, so as to kindle it, and then immediately cover it over with a quart or two-quart bell glass, so as to stand on the plate; the phosphorus goes on burning, the white smoke condenses against the sides of the cold glass, and forms showers of minute white crystals. Let the combustion go on as long as it will, and then, when the glass is cold and free from smoke, if you take it off, you will find that the whole, or nearly the whole, of these crystals, have fallen into the plate, presenting an appearance very like that of newly-fallen snow. This white substance is *dry*, or *anhydrous phosphoric acid*.

It has a very strong attraction for water, so that in the course of a short time, if exposed to air, it will lose its solid state, and become liquid, in consequence of dissolving in the water which is always present in the air.

If you put a drop or two of water on the dry acid, its strong attraction for that fluid will be manifested by a hissing noise, and the evolution of much heat, as the acid dissolves; and if you dip a bit of litmus paper into the solution thus produced, or into that just spoken of, you will find it instantly and powerfully reddened. This shows you that it is *acid;* and you may yet further convince yourself that such is the case by tasting a very minute drop of it.

The theory of the production of the acid in this experiment is simply this:—

Atmospheric air consists of nitrogen and oxygen; the combustion of the phosphorus is supported by the oxygen, and phosphoric acid is the result, whilst the nitrogen is set at liberty. You perhaps recollect that we availed ourselves of an experiment of this sort for the evolution of nitrogen on a former occasion, Vol. III., p. 173.

If you cause phosphorus to burn in oxygen instead of in atmospheric air, the combustion is far more vehement and splendid, but the acid result is exactly the same. As I have already furnished you with directions how to conduct the experiment, when speaking of the properties of oxygen, Vol. II., p. 189, it is needless to repeat them in this place.

The equivalent number of *phosphorus* is 16, and it combines with 2½ proportionals of *oxygen*, 20, producing 1 proportional of *phosphoric acid*, 36.

Phosphoric acid combines with bases, producing a class of salts called *phosphates;* the only one which we can at present examine is the *phosphate of ammonia.*

This salt you may produce by neutralizing the aqueous solution of phosphoric acid with ammonia (liquor ammoniæ), or carbonate of ammonia, and then carefully evaporating in the usual manner for the production of crystals, whose form will be that of an oblique rhombic prism, and consisting of 1 proportional of phosphoric acid 36, 1 proportional of ammonia 17, and 1½ proportional of water 13·5; its equivalent number therefore is 66·5.

Phosphate of ammonia is very readily decomposed by heat. Place a few crystals in a small earthen crucible, and heat it red-hot in the fire, then take it out, and hold a piece of turmeric paper at a little distance from its mouth, and that *ammonia* is evolving will be evident, by the yellow colour of the test paper changing to brown; heat the crucible again, until the evolution of ammonia ceases; then let it cool, add a drop or two of water, and dip in a piece of litmus paper; its blue colour will be changed to a bright red, showing that the *phosphoric acid* is left in a free state. The formation of phosphate of ammonia by the union of phosphoric acid with the alkali, as already described, is rather an expensive process, that is to say, if any considerable quantity is required, as in the following experiment; and therefore you had better purchase about an ounce of it at the operative chemists, who prepare it on a large scale and sell it at a cheap rate, for the purpose of rendering muslin and cloth incombustible, or fire-proof.

Make a tolerably strong solution of equal parts of the phosphate of ammonia and the muriate of ammonia; soak some slips of muslin, calico, or linen in it; take them out and dry them, then hold them in the flame of a candle, and you will find it impossible to make them burn with flame (as they would do if unprepared); they will only char or blacken, because the salts form a sort of glazing over their surfaces, which prevents the air getting to them in sufficient quantity to cause flame.

Cloth thus prepared is often useful for scenery, transparencies, &c.

Phosphorus combines with chlorine in two proportions, forming a protochloride and a perchloride; these are of very little interest, and therefore need not detain us, especially as the attraction of phosphorus for chlorine has been already noticed, Vol. II., p. 291.

The bromide and the iodide of phosphorus are also of very little interest; the formation of the latter has been shown when speaking of iodine, Vol. III., p. 140. Phosphorus and nitrogen do not appear capable of entering into combination.

We now come to a very curious compound of phosphorus with hydrogen, which is known as *phosphuretted hydrogen gas*.

In order to prepare it, take two or three sticks of caustic potassa (the *potassa fusa* of the shops); put them into a wine-glass full of water, and let them dissolve. A good deal of brownish froth or scum is thrown up during the solution, which may be skimmed off with a tea-spoon. The clear and strong solution you must pour into a small long-necked glass retort, so as nearly to fill its bulb. This being done, add to the solution six or seven bits of phosphorus, each about a quarter of an inch long, which you can cut off a long stick of phosphorus with a pen-knife; or, if you happen to have any bits already cut they will do as well. Then fill the neck of the retort *quite full of water*; place the finger over its end, and immerse the beak beneath the water of the pneumatic trough; apply the flame of a spirit-lamp very gently at first to the bulb of the retort; increase the heat by degrees, and you will find an evolution of gaseous matter taking place, which gradually forces the water out of the neck of the retort, and ultimately bubbles through the water of the trough. This is phosphuretted hydrogen gas; and its most remarkable character is its spontaneous combustion upon touching the air, so that as each bubble bursts on the surface of the water, it inflames with a slight explosion and bright flash of light, and a ring of white smoke ascends in the air.

If the air of the laboratory is perfectly calm and undisturbed, you will find that the ring of smoke is produced in great perfection, and that it gradually increases in diameter as it rises towards the ceiling. It consists of phosphoric acid and water, both of which are formed by the union of the phosphorus and the hydrogen of the gas with the oxygen of the air.

If you let a bubble or two of the gas up into oxygen, the flash of light is much brighter, but the experiment requires caution; it is best and safest done in the following manner:—Take a tall glass pint bottle or jar, fill it with water in the trough, and then transfer into it a four-ounce bottle of oxygen; place it on the shelf of the trough; hold it steady, and let a bubble of the gas from the beak of the retort rise into it; the instant that this is done, the bubble takes fire as it breaks into the oxygen, or if it does not, it will if you shake the bottle or jar; a second bubble may then be let up, and so on. But you must remember never to let up more than one, or at the utmost two bubbles at a time, otherwise the experiment becomes dangerous, and you would have an explosion which might shatter your apparatus to atoms, and perhaps injure your face or hands. Your fellow-student had better attend to the retort, and evolve the gas for you, whilst you attend to its reception and combustion in the oxygen; should he find the water rising in the neck of the retort (which is due to the condensation of steam from the boiling solution), he must apply the flame of the lamp a little stronger, so as to evolve the gas quicker; and during these experiments you will perceive a very *peculiar odour*, resembling that of garlic; it is that of *phosphuretted hydrogen*, and as it is very annoying to many persons, you should make the experiment either out of doors or in some outbuilding, or at all events somewhere where the whole house will not become contaminated with the odour, which lasts for a long time.

The gas burns spontaneously in chlorine, and you can make the experiment by following exactly the same directions as I have just given you regarding its combustion in oxygen.

Now you see the utility of filling the neck of the retort *quite full of water*, for, supposing that you had not done this, but proceeded to boil the solution of potassa in contact with the phosphorus, the instant that phosphuretted hydrogen was evolved, it would have burned in the *common air* contained in the neck of the retort, and produced an explosion which would have broken the retort, and dispersed the boiling caustic solution and the melted phosphorus in all directions.

I will now explain the reason why I directed you to remove the scum from the solution of potassa.

When perfectly pure, *potassa* consists of 1 proportional of potassium =40, and one proportional of oxygen=8, so that, strictly speaking, it is a *protoxide of potassium;* the *potassa fusa*, however, is not pure, and invariably contains a little *peroxide* of *potassium*, so that, when acted on by water, the excess of oxygen escapes, and forms the froth, whilst the protoxide dissolves. Now if this froth was not skimmed off, or if you simply contented yourself by putting the *potassa fusa* into the retort, and dissolving it there, you would have oxygen present, and so cause an explosion upon the evolution of phosphuretted hydrogen taking place.

You may collect and keep phosphuretted hydrogen in small bottles for a short time, and upon removing the stopper of any one of them, you get an instantaneous flash of light; but the gas is slowly decomposed when kept, and if left to stand over water, it loses its property of inflaming spontaneously.

From the best experiments that have been made upon this remarkable compound, it would appear to consist of 1 proportional of phosphorus=16, and 1 proportional of hydrogen=1; its equivalent number therefore=1.

The theory of its production by boiling a solution of potassa with phosphorus is this:—A decomposition of the *water* takes place; part of its oxygen unites with part of the phosphorus to form *phosphorous acid*, which unites to the potassa to form *phosphite of potassa*, whilst the hydrogen of the water unites with another part of the phosphorus to form *phosphuretted hydrogen* gas. When you wish its evolution to cease, withdraw the lamp from the bottom of the retort, and as it cools the water of the trough will slowly ascend and fill it, or very nearly fill it; if any gas remains, place your finger on the beak of the retort, remove it from the trough, and hold it in an upright position, so that the gas may rise into the neck, then take away the finger; the gas instantly burns, and all is safely finished; pour away the contents of the retort, but reserve the phosphorus, if any is left. You may keep it in the retort for the production of the gas at a future time, if you close the beak of the retort with a cork.

Phosphorus combines with sulphur, producing a *phosphuret of sulphur*, or a *sulphuret of phosphorus*, whichever you please to call it; but it is a compound of very little importance.

I have discussed all the compounds of phosphorus very lightly, because very few of them possess much interest; and, although phosphorus has been known for upwards of a century and a half, yet we know, I mean accurately know, very little of its combinations.

From what I have stated regarding the constitution of phosphoric acid, and of phosphuretted hydrogen, you will see that the equivalent, or proportional number, of phosphorus is 16. It is a simple or elementary body, and resists all attempts at decomposition, or resolution into other forms of matter. It enters into combination with many of the *metals*, forming *phosphurets;* and *phosphoric acid* unites to many *metallic oxides*, forming a numerous and important class of salts called *phosphates*. These, of course, it would be premature to consider, because the chemistry of the metals has not been yet considered. I may, however tell you that the phosphate of the oxide of calcium, or *phosphate of lime*, is the earthy or hardening principle of the bones of animals.

If you put a bone into the fire, it soon begins to burn and emit a very disagreeable odour, which is due to the decomposition of the animal matter (viz., fat, albumen, and gelatine); if you leave it for some time longer, until it is thoroughly red hot, and all these matters dissipated, you will find a white solid mass remaining, retaining somewhat of the shape of the bone, but very brittle; this chiefly consists of phosphate of lime, which being unalterable at the degree of heat which has decomposed the other matters, remains as a fixed residue.

This phosphate of lime, or *bone earth*, as it is very commonly called, is the source resorted to for the preparation of phosphorus, and the following account will give you a notion of the process, although it is one which you cannot be expected to conduct with any degree of profit or success, and therefore, at the outset of this essay, I advised you to purchase the phosphorus for your experiments at the "operative chemists."

Bones are burned or calcined, so as to obtain their phosphate of lime; this is ground to a tolerably fine powder, and digested with diluted sulphuric acid, which decomposes the phosphate, uniting with part of its lime, forming insoluble *sulphate of lime*, and liberating *phosphoric acid*, which remains in solution.

This solution is evaporated to dryness, and the dry mass is intimately mixed with charcoal powder; the mixture is put into an earthenware or glass retort, well coated with fire-clay, and placed in a furnace with its beak dipping into a basin of water. The retort is then heated bright red-hot, and at this elevated temperature the charcoal robs the phosphoric acid of its oxygen, and the phosphorus, being volatile, distils over in vapour, and is condensed in the form of small drops in the cold water. It is usually very impure and dirty, and therefore requires purification before it is saleable. This is effected by putting it into a small bag of chamois leather, which is then heated in water, so as to melt the phosphorus, and whilst under water, the bag is squeezed so as to force the phosphorus through the pores of the leather; it comes through clean and pure.

Phosphorus is formed into sticks by putting it into a glass funnel, having a very long neck, closed with a cork, and immersed in hot water, as *it melts, it runs into* and fills the neck of the funnel, which is then taken out of the water and allowed to cool. The phosphorus concretes into a solid state; the cork is then removed, and the stick of phosphorus thrust out by a bit of wire. In this preparation of phosphorus there are many manipulations required which cannot be entered into here; but the above is a general outline of the process.

The discovery of phosphorus was purely accidental, and was made by a German alchymist, named Brandt, in 1669; he was subjecting animal matters to distillation, at a very high temperature, in the hope of extracting from them some liquid or menstruum, capable of dissolving gold, or of aiding in the work of the transmutation of metals; instead of which, he elicited phosphorus, and kept its marvellous properties secret for a considerable time. Another alchymist, however, named Kunckel, obtained some hints regarding the source of Brandt's phosphorus, and immediately sold the recipe to Kraft, the alchymist of Dresden; he travelled to Brandt's laboratory at Hamburg, and paid him 200 dollars for the full and ample details of the operation; but during his absencé, Kunckel prepared and exhibited phosphorus, so that he might be regarded as its discoverer; and indeed, even till this day, it is commonly, yet unjustly, called *Kunckel's phosphorus*, whereas the whole merit of the discovery is due to Brandt.

In 1680, phosphorus was prepared in this country by Godfrey Hanckwitz, (under the direction of the celebrated Mr. Boyle,) at his laboratory, in Southampton Street, Covent Garden; and from this circumstance it received the name of *English phosphorus;* its new and singular properties excited so much attentioṅ, that Hanckwitz prepared it in considerable quantity, and set out on his travels to exhibit and vend it at foreign courts and laboratories.

In 1774, Gahn and Scheele made great improvements in the process for obtaining phosphorus, and succeeded in preparing it in large quantities; and at the present day, it is formed on a very large scale, and sold at a proportionably cheap rate.

There yet remains for our consideration, that most singular element, *Carbon;* but its history is too important to be abridged, or hastily considered; and therefore I must enter upon it at a future opportunity, and with the above history of phosphorus, I must conclude the present "Popular Course of Chemistry."

At its outset, I endeavoured to give you some account of the origin, progress, and present state of the science, to show you its intimate bearings upon natural phenomena, arts, and manufactures; I next directed your attention to the phenomena of attraction, in all its various forms, and proceeded to explain the true meaning of the term element; the language or nomenclature of the science, and the theory of definite proportions; and having done this, proceeded to the phenomena of chemical affinity, endeavouring to show you, by a few striking experiments, the principles upon which several of the arts are dependent for their welfare and success. Leaving this subject, that of pneumatic chemistry was introduced to your notice, by an examination of the gaseous elements, oxygen, chlorine, and hydrogen, and their combinations with each other. I then proceeded to iodine, bromine, and fluorine, and resumed pneumatic chemistry with nitrogen, and its important compounds; the chemical history of sulphur and phosphorus have now terminated the investigation.

I have endeavoured throughout, to furnish you with directions for conducting experiments with safety and success, and thus to enable you to gain some proficiency in the delightful and fascinating science of Chemistry, whose "beginning is pleasure; its progress, knowledge; it objects, truth and utility."

ON THE GEOGRAPHICAL DISTRIBUTION OF THE PLANTS WHICH ARE USED FOR FOOD.

(Concluded from p. 335.)

In order to elucidate these exceptions in their full extent, it will be necessary to take into consideration two circumstances neglected by the different authors I have just quoted.

1. In the experiments made at Paris in summer, solar light acted on the plants with much greater intensity than it ever acts at any season of the year between the tropics. It would therefore mature their development more under the same degrees of temperature. MM. Edwards and Colin took care also to water their plants regularly, which would cause them to grow better than under any ordinary cultivation. It is therefore probable that the restrictive action of the heat was somewhat diminished by these two causes, and, consequently, the limits admitted by those gentlemen are a little higher than they would have been found to be in the course of nature near to the tropics. It is difficult to estimate the action of the light, but it is probable, that if in the experiments the necessary humidity had been wanting, as happens from time to time in all cultivations, these species would have ceased to develop stems at 62° or 63°, instead of at 64½°, and the limit would have been found to have been between 61° and 68°, for example, instead of 64½° and 71½°. This consideration renders the exceptions of M. Humboldt more striking.

2. To explain how the Cerealia can flourish under mean annual temperatures of 77° to 80½°, it would be necessary to study the difference of temperature of the seasons, as has been previously done when treating of northern limits. There are countries in which European plants are sowed during the cold season which usually follows that of the rains, because they would not succeed if sowed during the hot season: this is the case in India, Egypt, and the Isle of Bourbon. Possibly this was the case with the cereals spoken of by M. Humboldt. It is clear that the absolute equatorial limit of an annual culture ought to be governed by the mean temperature of the coldest months, or rather the least warm ones, precisely as the polar limit is governed by the mean of the summer temperatures. Whenever it is annual plants that are under consideration, the agriculturist is governed by the climate in selecting the season for sowing; in cold countries he sows for summer; in hot for winter. In Bengal, wheat, barley, oats, beans, &c., are sowed in the month of October, and the harvest is gathered in March and April. The products of hot coun-

tries follow, as rice, indigo, cotton, and maize, which are began with the rains in the months of May and June, to be gathered in October[*].

It is therefore necessary to know if, in intertropical countries, there be not a season of the year in which the mean temperature is low enough to admit of the cultivation of our Cerealia, and particularly if this be not the case in those places mentioned as exceptions by M. Humboldt.

Accurate thermometric observations are not common out of Europe; nevertheless, they prove that in many parts within the limits of the torrid zone, the temperature of the cold season permits the culture of the Cerealia. Thus we have—

	Latitude.	Mean Annual.	The Three Months.	
			The coolest.	The hottest.
	°	°	°	°
At the Havannah[†]	25 N.	77·5	71·3	82·2
At Rio de Janeiro[‡]	22 S.	74·2	68·7	78·8
At Cairo[§]	30 N.	72·5	57·5	84·8
At Macao[‖]	22 N.	74·0	65·0	82·3
At the Isle of Bourbon[¶]	21 S.	77·0	71·9	79·8

In all these localities, where the mean annual temperature lies between 72½° and 78°, the cultivation of the Cerealia, especially that of wheat, would be practicable, owing to the temperature of winter, if we set out from 71½°, the limit adopted by MM. Edwards and Colin: and thus the cultivation of wheat in the island of Cuba would no longer form an exception. If the limit 71½° be considered as too high a maximum, it would nevertheless be true that in such localities as Macao, Cairo, and Rio de Janeiro, where the temperature is from 71½° to 74°, the cultivation of wheat would be practicable.

Moreover, by adopting the cultivation on hills, or in valleys, turned towards the north, only two or three hundred feet above the level of the sea, that is at an elevation which travellers often confound with the plains on the level of the shore, as not worthy of notice, a suitable winter temperature might easily be found in Cuba, Guatimala, in the Isle of France, and elsewhere between the tropics[**].

The isochimenal line of 68°—70°, which appears to constitute the furthest limit of wheat culture towards the equator, fluctuates between 20° and 23° of latitude. As we approach the tropics, the lines of temperature of the different seasons, and of the whole year, approach each other and become more parallel, yet, within the tropics, the inequality of the seasons is not insignificant as it becomes near the equator[††]. The isochimenal line of 70° passes far from Macao towards the 20° of latitude at furthest; in Egypt and in Cuba it lies about 21°—22°. In the southern hemisphere, in America, it appears to keep between 22°—23° of latitude. This limit only affects wheat; other cereals, especially barley, stop farther from the equator, since they only endure a temperature from 5° to 7° lower than that of wheat. The distance which separates the southern limits of these cultivations, is but little known and vaguely ascertained, not only on account of the countries through which these limits pass, but also because the Cerealia are of much less importance in the torrid zone than in ours. Agriculturists cultivate in those regions too a great number of more useful species than wheat or barley not to neglect these last; it is therefore probable they have rarely been carried to their extreme limits.

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[*] *Boyle: Illustrations of the Botany of the Himalayan Mountains, Intro.*, p. 10. *Thomas: Statistics of the Isle of Bourbon*, ii. p. 12.

[†] *Humb.*, xii., p. 197.

[‡] *Humb.*, xiii., p. 106.

[§] *Humb: Isoth. Lines*, p. 516.

[‖] *Humb: Frag. Asiat.*, ii. p. 63.

[¶] *Thomas: Statistics of the Isle of Bourbon.*

[**] At Ubajay, a village situated at five leagues from the Havannah, and only at fifty yards above the level of the sea, the temperature of December and January is 64°·5, according to observations made by Bobredo. (*Humb. Essay Pol. on Cuba*, i., p. 88.)

[††] The traveller is not so much struck with the diminution of the mean annual temperature, on going from the equator towards the tropics, as with the unequal distribution of heat over the different seasons of the year. (*Humb. Voy.* xiii., p. 195.)

RICE.

RICE (*Oryza sativa*) has been cultivated in the southern regions of Asia from the remotest antiquity; these are probably its original country, although, from causes before indicated, it is no longer found there undoubtedly wild*. It yields so great a proportion of fecula, that its cultivation would be extended everywhere, if two conditions, rarely found together, heat and humidity, were not essential to it.

A summer temperature of 73½° at least, with abundance of water, is only found in few localities between the equator and 45° of latitude. I deduce these limits of summer temperature and of geographical position from Piedmont, which presents the example of the most northerly rice cultivation.

Rice constitutes the staple nourishment of the Japanese, the Chinese, of various Indian populations, and of the adjacent islands (at least near to rivers), of the negroes of Madagascar, of the coasts of Mozambique and of Guinea, and, lastly, of the inhabitants of Louisiana, omitting some other districts of less extent. It is perhaps of all plants that which nourishes the greatest number of human beings. and one of those which, on a given surface of ground, produces the greatest quantity of nutritive matter; relatively to the weight of grain, the quantity of fecula is greater in rice than in corn, maize, or the potato; consequently it is more advantageously exported than any of those plants. This circumstance, joined to the specific physical conditions, limits the cultivation of rice to districts which are very favourable to it, and renders it universal, or even exclusive, within those districts.

MILLET AND SORGHUM.

DIFFERENT species of the genera *Holcus* and *Panicum* (Graminaceæ) are objects of agriculture in countries south of the 45°—47° parallels of latitude; they supply some populations even exclusively with nourishment, though not very beneficially.

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* Roxburgh (*Flora Ind.*, iii., p. 201, 2nd edition; Serampore, 1832) asserts having found rice wild in the province of Circars, on the margins of lakes, and that it is a variety much esteemed by wealthy Hindoos, but not cultivated on account of its small produce. I should like to compare the two plants before admitting the specific identity of this wild, and of the cultivated rice; or to have the testimony of some modern botanist, more skilful than Roxburgh in the investigation of such matters. In Dr. Wallich's catalogue of the East India Company's herbarium, there is no mention of the plant of Roxburgh.

The Breton peasantry principally consume buck-wheat (*Polygonum fagopyrum*, *Polygonaceæ*), and the grain of the *Panicum miliaceum*, of which they make a *bouillie* (*grans*). In Italy, especially in Tuscany, the peasantry make great use of sorgho (*Sorghum vulgare*, formerly *Holcus sorghum*). These species of grasses, little productive as they are, are generally cultivated in Africa and India.

CHESNUT.

THIS fruit constitutes the habitual food of the inhabitants of Limousin and Perigord, and of some districts of the Apennine chain; everywhere else it is only an accessory, or even an article of luxury.

The chesnut (*Castanea vesca*) grows spontaneously in all the mountainous regions of Southern Europe, in Asia Minor, and in Caucasia, as far as the river Terek*. Out of its natural country it is cultivated as a fruit-tree to a certain latitude: further north still, it constitutes an ornamental timber-tree, the wood of which is used on some occasions. Thus in England, north of London (51°), it does not ripen its fruit, but it constitutes an ornament of most parks. In Belgium, the environs of Brussels form the limit to the fruit-bearing chesnuts. In Germany, its limits appear to coincide with those of the vine, which advance near to Leipsic Dresden, as far as 51¼° latitude. I do not know whether the chestnut yields ripe fruit in Poland, but it is mentioned as growing in the Ukraine, towards 50° latitude.

The chesnut being a *tree*, and not an annual plant, as those which have been before described, is commonly controlled as to its northern limit by the cold of the winters; nevertheless, in countries such as the West of Europe, the climate of which is equal, the heat of summer is more inadequate to ripen the fruit than the cold of winter to prejudice the plant. Like the vine, therefore, it is limited in Western Europe by a line nearly isochimenous.

The chesnut also suffers from heat, for even in Italy it only grows on the slopes of mountains, and is not met with in the chain of Atlas. The chesnut of America is another species.

The remaining plants now about to be discussed have no southern limit towards the equator.

THE DATE TREE.

THE date (*Phœnix dactylifera*) of the order Palmaceæ, or palm family, is a native of Northern Africa, and yields one of the most nutritive fruits in existence. It grows spontaneously in abundance on the southern flanks of the Atlas chain, whence the Arabs give the name of "The Date Country" to a confined zone between this chain and the desert.

Though a dry hot climate best suits it, yet it is cultivated on the African coast of the Mediterranean, on the banks of the Nile, and in the Canary Islands, countries where the aridity is inferior to that of inland Africa. It is also to be found in the most burning regions, as of Sennaar, Arabia, the shores of the Persian gulf, &c. Each tree annually yields from 150 to 280 lbs. of fruit.

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* *De Candolle: Nar. of a Bot. and Agricul. Journey in the S.-East and S.-West*, pp. 45–51.

The date palm, like the chesnut and vine in the West of Europe, has two northern limits; beyond a certain line, its fruit does not ripen, but it may be yet cultivated for its leaves, with which churches are ornamented; and an isochimenal line, situated still further north, completely arrests the vegetation of the tree.

The maturation of the date does not take place beyond the southern provinces of Portugal, the environs of Valencia (39°), the northern coasts of Africa (37°), Southern Sicily (37°—38°), Corfu? (39½°), Syria and Mesopotamia (34°—35°), Southern Persia and Beloutchistan (29°—30°), and the banks of the Indus (32°—33°). As the date ripens from the month of February till autumn, the mean temperature of nine months of the year ought to be the same on this line: that of winter can have but little influence, but as it concurs in the determination of the annual mean, the limit of the fruit-bearing dates must not be referred to an isothermal line without undergoing a slight modification. Thus, when M. Arago concludes, from the ancient limit of the date, that the mean temperature of the year was formerly 70° in Palestine, because it is nearly that at Algiers, a country near to the limit of dates, we cannot regard this deduction as conclusive; it may vary from the truth two or three degrees, which deprives it of its value for the particular object of the researches of this illustrious *physicien;* at all events, the ingenious reasoning which all the world has read, in the *Annuaire du Bureau des Longitudes*[*], only directly demonstrate the stability of climates for nine months of the year, those of November, December, and January not being included.

Moreover, the isochimenal and isotheral lines are sufficiently parallel over the whole extent of the Mediterranean, to show that the temperature of the nine months of which I speak is nearly coincident with an isothermal line. Thus we find on the limit of fruit-bearing dates, in Portugal about 62½° of mean annual temperature, in Barbary about 62½°, in central Sicily 63½°, in Palestine 64½°, as far as we are authorized in concluding from the observations, often imperfect and incomplete, of Lisbon[†], Algiers, the South of France, Cagliari, Palermo, and Canaan.

The date tree, cultivated for its leaves alone, advances in Spain to the 41°; in France and Italy on the southern shores of Hieres to Genoa, where it excites the admiration of travellers, especially near Bordighierra; in Greece, at Athens; and to Smyrna. As regards the points of this line of which the mean temperature is known, it appears that it is about 61°·7 of mean annual, and of 48° mean winter temperature. This latter figure appears to me of more importance than the former, because it is probably the cold of winter that arrests the cultivation of the date further northward. It may be concluded from this fact, that the mean winter temperature of ancient Palestine could not be below 48°*.

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[*] The article here alluded to was given in the *Magazine of Popular Science*, Vol. III. p. 81.

[†] At the time when M. Arago wrote the article alluded to, the temperature of the coast of Algiers was not well known. M. Humboldt assigned 70° of mean annual temperature, from ancient observa*tions; but M. Rozet*, a French officer, *who appears to* have made very exact observations, found 61°·3 to be the mean temperature of the cisterns of the city of Algiers; and the atmospheric observations which he gives for many months of 1830, indicate temperatures 3°·5 to 5° lower than those formerly attributed to it. (*Travels in Algiers.*) The temperature of the seasons at different points of the Mediterranean coast is still but little known.

The Banana.

The Bananas (*Musa sapientium* and *paradisiaca*) of the order Musaceæ appear to be originally from the southern portions of the Asiatic continent†. Transported at some unknown period to the Indian Archipelago and into Africa, they have spread themselves also in the New World, and in all the intertropical regions generally some time previous to the arrival of Europeans in America.

The banana is a saccharine fruit, containing much fecula; according to M. Humboldt, it yields 44 times as much nutritive matter for a given extent of country as the potato, and 133 times as much as wheat. These numbers, deduced from the weight of matter gathered, ought not to be literally adopted, since nothing is more difficult than to estimate the mean produce of any cultivation, and especially the nutritive qualities of different aliments. The discussions on gelatine, which are yearly renewed, sufficiently prove this.

Musa paradisiaca is cultivated in Syria as far north as 34°, according to M. Bové‡. I presume that in this case the limit is determined by the winter cold, for the summer heat ought to exceed 77°. In equatorial America, according to M. Humboldt, the banana§ ceases to yield fruit at 1500 yards of elevation, where the mean annual temperature is of 68°, and where, probably, these plants have not sufficient summer heat. There is moreover a great number of varieties, which are perhaps distinct species, each requiring different conditions of temperature. The observations of M. Boussingault‖ agree very closely with those of M. Humboldt, only they appear to have been made at other points of the Cordilleras. He states that the fruit ripens with difficulty at 2000 yards elevation in those portions of the chains of the Cordilleras where the mean temperature is from 64½° to 66°, and that it ceases to ripen at 2400 yards under a temperature of 61°, but that it is, nevertheless, cultivated as high as 2600 yards under a temperature of 59°, but then only as an ornamental plant, or else for some particular use of the leaves and stem.

Cocoa-nut.

The beautiful palm which we call the cocoa-nut tree (*Cocos nucifera*), came originally from the south of Asia. It has been spread by cultivation over all the intertropical regions of the Old and New World, but it is nowhere cultivated so abundantly as in the isles of Ceylon, of Sonda, &c. It advances as far as Mocha, on the shores of the Red Sea, according to Niebuhr, but it does not appear to succeed in Egypt. It is cultivated in

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[*] It appears that we ought in this case to seek the absolute extremes of cold rather than the means of winter, since there is a certain point at which every plant freezes. What ought to lead us away from this consideration is the circumstance that each degree of cold acts in a different manner, according to the epoch at which it occurs, its duration, and the degree of humidity at the period of its occurrence.

[†] *R. Rrown: Botany of Congo*, p. 51.

[‡] *Ann. des Sci. Nat. 2 Series*, i. p. 339.

[§] *Prolegomena*, p. 55.

[‖] *Acad. des Sciences de Paris*, 2nd May, 1836.

the lower and the more southern portions of the Asiatic continent, for example, on the Coromandel and Malabar coasts, and round Calcutta. The island of Ceylon, where it constitutes one of the principal sources of food of the inhabitants, possesses the cocoa palm in such abundance, and lies so near to the elevated regions of the Indian peninsula, where it does not exist, that in the year 1809, for example, 2,977,275 nuts were imported at 13*s*. 4*d*. sterling per hundred [*]. According to Marshall, a mean temperature of 72° is necessary to the cocoa-nut; its northern limit consequently is nearly the southern one of our Cerealia. It ought to agree with the mean temperature of a certain part of the year rather than with that of the whole year, but writers have not paid attention to this subject.

All the world knows the cocoa-nut to be one of the most valuable plants which exist; its wood is useful in building; mats, brooms, nets, pins, torches, oars, &c., are made from its leaves; houses are thatched, and tame elephants fed with them; sugar, vinegar, or wine, are obtained at pleasure from the sap without detriment to the plant. The kernel of the nut is at first a wholesome and refreshing milk, and afterwards a nutritious substance, sufficient for the nourishment of hard-working men, and lastly a fine oil is extracted from it, which, in many countries, is the only one used. It is not astonishing therefore, when travellers inform us that groups of cocoa-nut trees shade all the huts in India, and in the Southern Ocean; "The inhabitants of the coasts of some islands in the torrid zone," says Mr. Marshall, "are rather palmivorous than graminivorous;" and he adds, "when a people possesses a nourishment as abundant and as easy to procure as that of the cocoa-nut, it is but little affected by those motives which compel others to labour."

Bread Fruit.

The bread fruit (*Artocarpus incisa*), of the order Urticaceæ, is a tree indigenous to the isles of the South Sea, lying near the equator. The primitive plant, which is cultivated, for example, in the Celebes, contains well-formed seeds in the pulp of the fruit. In the variety most generally cultivated, on the contrary, the kernels are always abortive, as happens with the fruit of the ananas; indeed, there are many analogies of structure between these plants.

The bread fruit is generally disseminated in the archipelagos of the Friendly, the Society Islands, the Carolinas, &c.; the fruit is eaten either raw, or cooked and dressed in a variety of modes. It furnishes a considerable quantity of nutritive matter, yet less than the banana, according to M. Humboldt. Unfortunately, this tree is very sensitive of cold, and hardly extends to the 22nd or 23rd degrees of latitude. It has been transported to the Isle of France, the mean temperature of which is 78° on the coast, and where the range of the thermometer from the coldest to the warmest month is only 9° or 11°. It has been introduced in the Antilles, in Brazil, and at Rio de Janeiro, where the coldest month has a temperature of 67°, and the hottest one of 81°[†]. It was also carried into Cayenne by the same vessel that conveyed the unfortunate exiles of Fructidor.

[*] *Marshall: Hist. of the Cocoa-nut; Mem. of Wern.*, Soc. at Edinburgh, v. p. 107.

[†] *Humb. Frag. Asiat.*, ii., p. 360.

THE SCREW PINE.

THE fruit of the *Pandanus odoratissimus*, or screw pine, of the order *Pandanaceæ*, constitutes the principal nourishment of the inhabitants of the isles of Badak and Carolina, at least during a part of the year; it is farinaceous, but inferior to the bread fruit.

B.—*Plants cultivated for their Roots.*

TARRO (*Arum*, or *Caladium*, *esculentum*) (*Araceæ*).

THE root of the *Arum esculentum* is the habitual food of the aborigines of New Zealand, and of some others of the South Sea Islands, as, for example, the Sandwich Islands, in which it is called *tarro* or *tarra*.

Tacca pinnatifida (*Araceæ*).

THE root of the tacca is still more employed; it is indigenous in Madagascar, and some islands of the South Seas; in the former it is named *tavoulon*.

It probably nowhere constitutes the sole, or even the principal nourishment of a population, but is united with others, especially rice, at Madagascar, and with the cocoa-nut and bread fruit in the Society Islands.

Pteris esculenta (*Filices*).

THE root of this fern is eaten in most of the South Sea Islands.

YAM.

THE yam (*Dioscorea alata*), of the order *Smilaceæ*, has an enormous black root, white internally, often weighing as much as thirty pounds, and containing much fecula; it is eaten cooked, in all the manners in which farinaceous food is prepared. It is indigenous in the islands of the Indian archipelago, where it is extensively cultivated; it is not found at more than 10° of lat. on either side of the equator in the Old World. The yam is little cultivated in America, except in Cuba, where it forms a principal object of agriculture.

BATATA.

THE batata (*Convolvulus batatas* or *Batatas edulis*) is generally cultivated for its root in all intertropical countries, and as a vegetable in temperate climates. The cultivation on the large scale ceases in Carolina, in the United States, at lat. 36°; it is reared in Spain and Portugal to the 40°—42° of lat., and its culture is even attempted as far north as Paris as a vegetable. It is a native of India.

The batatas must not be confounded with the Jérusalem artichoke (*Helianthus tuberosus*, Asteraceæ), which is less cultivated*, nor with the potato, which has usurped its name in many languages.

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* In Britain it is just the reverse: the batatas is not cultivated at all, our island lying in too high a latitude, while the Jerusalem artichoke is very general in gardens.—*Translator.*

II.—SPECIES INDIGENOUS TO THE NEW WORLD.

MAIZE (*Zea Mays*), Graminaceæ.

THE origin of maize is a question that has been long discussed, and remains still unanswered; my opinion inclines to assign it to America, since M. Auguste de St. Hilaire asserted that he had met with wild maize in the forests of Brazil; but M. Bonafous, in a recent work on this plant*, maintains the other hypothesis, of an Asiatic origin. He endeavours to demonstrate that maize was cultivated in India and Egypt long before the discovery of America; so that either it must have been indigenous to both worlds, or formerly transplanted from America to Asia before the arrival of Europeans.

Maize is hardly at all now cultivated in the equatorial regions of America at above 2400 yards†, which would imply a mean temperature of 59° to 62½°, and a summer one of from 64½° to 68°. The actual northern limit of maize culture‡ in Europe is as follows, when it is cultivated in open fields for its grain, and not merely as forage. From the shores of the Atlantic the limit starts from the environs of Bourbon in La Vendée, between this city and Nantes, at 46¾°—47° of lat.§ It is raised abundantly between Mans and La Flèche (48° lat.) as food for poultry; from hence it is difficult to trace the limit round Paris as far as to the north of Frankfort on the Maine‖ (50½°); further on I can find no mention made of it in the local Floras of Bohemia and Moravia, nor in works on botanical geography, but M. Besser informs us that it is cultivated in abundance on the banks of the Dneister, four miles from Zalesczyki, on the road from Buczacz in Gallicia, that is to say, about 49° lat. Further eastward its limit is unknown.

Maize being an annual plant, only requires heat during summer, winter having no influence over it; it follows that its limit, compared to that of the vine, presents the same phenomenon as those of wheat, apples, and pears. The two limits cross towards the centre of Europe. In the west, that is in France and Germany, the limit of the vine lies about twenty or thirty leagues north of that of maize; it would be still further removed if commercial and agricultural causes foreign to all considerations of climate had not caused the vine limit to recede towards the south. To the east of the Krapack mountains we find, on the contrary, maize about twenty leagues to the north of that of the vine¶.

The temperatures on the limit of maize are,

		MEAN TEMPERATURE, FAHR.		
	LAT.	The Year.	Winter.	Summer.
Dep. of La Vendée	46¾°	55½°—56¼°	40°—41°	66°—67°
Paris - - - -	48¾°	51·5°	40°	64·5
North of Frankfort	50½°	49·7°	33·9°	65·5°—66°

These numbers are neither so complete nor so satisfactory as would be desirable, because at those points where the limit of maize is best ascertained, as in La Vendée and Mans, thermometric observations have not been made with great precision; nevertheless, it is perfectly clear that it is summer temperature which most influences this limit, and that maize nearly follows an isotheral line of 66°, varying half a degree either way from causes not known.

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* A folio volume; Paris, 1836.

† *Humb. Tabl. Phys.*, p. 143.

‡ *De Candolle: Relation of a Voyage in the West of France*, p. 129.

§ *Floras of the Maine and Loire.*

‖ *Flore Econo.* of Wettereau.

¶ This is at Mohilew, on the Dneister.

According to these observations, it is probable that the culture of maize extends, or might be extended, into Southern Russia, and into Poland, further than the limit indicated; in fact, the isotheral line of 66° traverses Poland to the north-west of Warsaw, and continues to turn northward as far as Moscow (56° lat.), and it is only from this point, where the means are 56°·5 for the year, 53° for winter, and 66°·5 for summer, that this isotheral line returns towards the south-east.

The cultivation of maize in Europe being new, compared to those of wheat, barley, or rye, it is not astonishing that in those countries which are not populous, and where agriculture is not far advanced, as Southern Russia for example, the cultivation of this plant has ample space to advance towards the north. Even in France the limit has advanced forty or fifty leagues since the epoch when Arthur observed it, so that the region which he distinguished, as that of the vine without maize, is hardly now distinguishable. Commercial reasons having caused the vine to retrograde, and exercising no influence on the cultivation of maize, the limit of the vine will some day be found to the south of that of maize, provided the custom-house or some maritime war does not interfere to stop this natural progress of events.

Maize is cultivated more frequently in North America than in Europe; it is there seen even in high latitudes, thanks to the extreme inequality of the seasons in the most populous parts of the Union, that is, the eastern part of the continent. According to Warden (*Description of the United States*), maize is cultivated over all North America, including, of course, part of Canada, as well as the United States, the only countries where there are cultivators; and if there be no error in Captain Franklin's* statement, it is even grown in the interior of Canada at 54° lat. As to the elevation on mountains, which this cultivation attains, it must be observed that ground on a slope or too dry is unfavourable to maize, and consequently the culture has not been carried so far in such situations as temperature would allow of its being. Moreover, the mean temperature of the seasons is so little known for different elevations, that all comparisons between various cultures with regard to elevation are grounded on fallacious data. In France, the highest point at which maize has been hitherto observed is the village of Lescans (Pyrenees), situated about 1000 yards above the level of the sea†, a limit rather beyond that of the vine, this last not exceeding 800 yards of elevation; but perhaps this may be attributed to commercial causes, which, as already stated, exercise more influence on the vine than on an alimentary plant like maize. The bad wines of the mountains of the South of France cannot compete with those of the plains, hence the vine cultivation is not carried as far in respect to elevation as temperature would admit.

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* *Voyage*, 4to. 176.

† *De Candolle: Memoir on the Geog. Dist. of the Plants of France.*

QUINOA (*Chenopodium*).

QUINOA was an object of extensive cultivation in the elevated regions of Peru before the arrival of Europeans, and since then the use of this inferior species of grain has continued among the aborigines, but our Cerealia dispute the soil with the humble chenopodium, which we have never thought worthy of our attention in Europe. It is an annual, and readily ripens its seed in the open air in our botanic gardens, where it is cultivated as an object of study or curiosity.

ARRACATCHA.

THIS umbelliferous plant is cultivated in the mountains of Vénézuela conjointly with the potato. It has been transported into some European gardens, in particular that of Geneva, whence it has been accurately described for the first time*; it vegetates there, but does not form produce, which consist in tuberous stems abounding in fecula. The plant supports cold better than the potato, but it requires a warmer and more equal climate than ours to flourish. It would be worth trying at Naples.

THE POTATO.

THE culture of this plant (*Solanum tuberosum*) was general in America at the epoch of its discovery, but it is only within a few years that the original country of the species has been ascertained. M. Humboldt had sought in vain for it in the mountains of Peru and New Grenada†, where it is cultivated along with the *Chenopodium quinoa*. Before him, Ruiz and Pavon, Spanish botanists, who had a long time dwelt in Southern America, asserted that they had found the potato on the hills in the neighbourhood of Chancay, a city on the coast of Peru‡; but since the travels of MM. Humboldt and Bonpland, doubts were entertained on this point. It might be believed that the plants were not spontaneous, but Pavon insisted on the truth of the assertion in the *Flora Peruviana;* he wrote to M. Lambert, as follows, "The solanum tuberosum grows wild in the neighbourhood of Lima, on the coast fourteen leagues from this city; I myself have found it at Chili." He even sent M. Lambert tubers of the plant, which he believed to be wild. Mr. Caldcleugh confirmed the testimony of Pavon, and sent, some years ago, wild tubers from Chili to the Horticultural Society of London. Lastly, Mr. Cruikshanks, to whom the botany of Chili is indebted for many additions, wrote to Dr. Hooker, at the close of 1830, the following observations made on the spot:

"The fact is often objected, that in the countries where the potato grows wild, it may have been introduced, and not be an indigenous species, as has been the case with other plants in America; there are, nevertheless, many reasons for believing that it is native in Chili, and that the specimens which are met with wild are not the accidental descendants of cultivated plants. In that country, they are commonly met with on steep rocky slopes, which never could have been cultivated, and to which no accident could have transported the seeds. This wild potato is very common at Valparaiso, and I have traced it on the coast to fifteen leagues north of this city, but I do not know how far beyond it extends either to the north or south. Its habitat is especially the downs near the sea coast, and I do not recollect ever having seen it more than two or three leagues inland. There is one circumstance I have never seen mentioned in books, this is, that the flower is always of a pure white, without trace of that purple tint so prevalent in the cultivated varieties—a fact I regard as a strong proof of its spontaneous origin[*]. I deduce another proof from this fact, that it is often found in mountainous places far from all cultivation, and that it is not seen in the immediate neighbourhood of fields or gardens in which the potato is cultivated, *unless there is a stream of water which may convey some tubers into uncultivated regions.*" Mr. Cruikshanks conceives that the wild potatoes of the neighbourhood of Lima only owe their origin to such irrigations; he observes that, near to Chancay, the river Pasamayo often overflows the land, and consequently the observations of Pavon will only be applicable to those specimens really found on the hills incapable of cultivation.

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* *De Candolle: on the rarer Plants of the Botanic Garden at Geneva*, in the *Mém. de la Soc. de Phys. et d'Hist. Nat.*

† *Essay on the Geography of Plants*, p. 29.

‡ Flora Peruviana.

It appears from the learned researches of M. Dunal[†], that the Spaniards had brought the potato to Europe before Raleigh imported it, as all the world knows, from Virginia into England in 1586. The celebrated botanist Clusius, or L'Ecluse, who first described it in 1591, had cultivated it in the garden which he superintended in Germany as early as 1588; he states that he received it from Italy, where it had been for some time cultivated for food for man and domestic animals. Now, Raleigh's departure for America took place in 1585, and supposing the potato to have been introduced into England very soon afterwards, it is not easy to comprehend how the use of the plant could have been established in Italy before 1588. At that epoch agricultural innovations were far less rapid in their progress than they are at present, and even now we well know how slow they are.

From 1714 to 1724 the potato was introduced into Swabia, Alsace, and the Palatinate; in 1730 into the canton of Berne, and in 1767 into Tuscany. It had extended itself but slowly in France, when Parmentier gave so great an impulse to it in the second half of the last century, that his name was about to be bestowed on it. The dearth of 1793 contributed to spread it still further—so true is it that even calamities bring attendant benefits. The potato has only been introduced into Iceland and some mountainous valleys of Europe in our own days[‡]. According to M. Humboldt, the cultivation of the potato is general in the Andes at between 4000 and 5000 yards of elevation. The expressions he uses might lead one to suppose that these numbers are given as round ones, and that the potato stops more exactly at 4600 yards or about 300 yards above the limit of wheat, and nearly at the same altitude as barley.

In our mountains of Switzerland, the cultivation of the potato, which is carried as high as possible, rises, according to M. Rastoffer, in the canton of Berne, to 4500 feet; he fixes that of winter corn at 3400, of barley at 3500, of rye at 4600, and of barley at 4800. I am inclined to believe, nevertheless, that there are very few fields of barley at a greater elevation than those of potatoes. One circumstance that may produce an error in determining the possible limit of the potato is, that its culture is every where near habitations, for reasons foreign to all considerations of climate, and that the habitations on the Alps are rather below the limits of agriculture.

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[*] The author should have stated why he regarded this as such a proof.

[†] *History of the Solanum.*

[‡] An inhabitant of the canton of Uri, deserving of credit, assured me that the potato had not been cultivated in his country for more than ten years, which, nevertheless, is one of those to which this plant can impart the greatest services. In agriculture, as in every thing else, the absolute democracy of the smaller cantons is little friendly to progress.

Towards the north of Europe it appears that the potato cultivation is extended a little beyond that of barley, and consequently of all the Cerealia; thus a precocious variety has been introduced into Iceland, where barley will not thrive. The potato is the only food I found in the miserable huts of the Hebrides, a country where, with some skill and labour, some cereals might be cultivated. In Norway, the potato, as well as barley, extends to the northern extremities of our continent. In Russia its limit is not known. It is clear that, for these northern countries, the cultivation of *early* varieties is an essential object, and it is probable that, from the care bestowed to obtain them, the culture of this plant may advance yet further northward, and still higher up mountains.

It is known that this invaluable vegetable readily degenerates in warm countries. The English, more attached to their habits than all other nations, are resolved to eat potatoes in all their colonies, and have succeeded in so doing by cultivating them in mountainous regions, or with certain rules appropriate to each climate. It is said that the potatoes introduced into Bengal by the curators of the Botanic Garden at Calcutta, are not bad; nevertheless I doubt if the plant would succeed in the intertropical plains of Africa and America, where the temperature varies less than in Bengal from one season to another, and where, also, there is often not sufficient humidity.

MANIOC.

THE *Jatropha*, or *Janipha manihot*, of the order Euphorbiaceæ, is a shrub, the large fleshy root of which yields a considerable quantity of fecula; this root contains a juice which is a violent poison in one variety, but the poisonous principle is dissipated by cookery. The manioc is indigenous in Brazil, and it is cultivated in America to about the thirtieth degree of latitude. On both sides the equator, like the banana, it stops at about an altitude of 1100 yards in the mountains of the intertropical zone of America. The jatropha is also cultivated abundantly on the western coast of Africa, in Congo and at Guinea, probably owing to ancient intercourse between the negroes and America, or from some other unknown source of conveyance*. It has not been introduced into Asia apparently.

The farina of the manioc is almost the sole one that is consumed in Brazil, at least towards the north, near the equator. It is employed in the remainder of America, where the different preparations of the farina called *Cassava* in some colonies, are much esteemed. According to Rochefort, an acre of manioc yields as much nourishment as six of wheat.

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* *R. Brown*: *Bot. of Congo.*

If we consider the Old and New World generally, with regard to this subject, we shall find that the species proper for man's nourishment were primitively divided tolerably equally, in proportion to surface, but on closer examination we find striking diversity in this respect; Southern America, and the south and centre of Asia present an astonishing variety of useful species; Europe, the north of Asia, and America, Africa, and especially New Holland, on the contrary, present the remarkable contrast in an almost complete dearth of alimentary plants of any importance. Human industry has filled up these vacancies, it has extended far towards the north the Cerealia, maize, and the potato; while, owing to the more favourable climate between the tropics, the naturalization of plants have been more numerous and more important.

Nevertheless, the cultivations of the intertropical countries are far from being so varied as they might be in each locality. The civilized races who inhabit the temperate regions have alone comprehended the value of a varied cultivation for diminishing the frequency of famines. If we escape this cruel scourge, we owe it to the number of our annual cultures, determined by the circumstance of certain herbaceous or ligneous plants being incapable of withstanding the cold of our winters. The annual plants conform admirably to the conditions and to the demands of each season in each locality. They speedily supply the deficiency of another produce that has failed, and give rise to a judicious succession of crops. Let us add, also, that the recurrence of scarcities is perceptibly diminished by the wealth and security enjoyed by our European agriculturists, by the facility of transport, and by the happy protection of the laws, which enables them to store up produce till the time when a diminution in quantity produces a rise in price.

As to the employment of alimentary substances, it would, doubtless, be an interesting question to ascertain what proportion of the human race is nourished by each plant, and what quantity of nourishment may be obtained from a given area cultivated in different manners; but many data are wanting, to allow of an answer to these questions, which are far more complicated than might at first appear, and which are foreign to the domain of botanical geography. It is also well known that populations accumulate and increase, not only according to their means of nourishment, but according to their industry, commerce, civilization —according to their means of *existence*, in a word, and not of their subsistence. Let us, therefore, here terminate our review of alimentary plants, and leave these questions to the political economist.

A POPULAR COURSE OF GEOLOGY.

XIV.

TERTIARY STRATA.—PLIOCENE.—MIOCENE.—EOCENE.

In describing the primary rocks, we have worked our way upwards to the base of the Cambrian system, or commencement of the fossiliferous series. In treating of the fossiliferous strata, it will be most convenient, and most consonant to established usage, to commence at the surface, and take them in the descending order. We shall begin, then, with the tertiary strata, or those beds newer than the chalk which contain some existing species of molluscs, but which cannot be proved to have been formed since the earth was inhabited by man.

Tertiary Strata.

Superior order, Conybeare; *Supracretaceous Group*, De la Beche; *Newer and older Pliocene*, *Miocene*, *and Eocene*, Lyell; *Tertiärgebilde* of German authors; *Terrains de Sédimens Supérieure*, of the French.

The tertiary strata are, on the whole, distinguished from the secondary by their lithological characters; they are, for the most part, less consolidated, consisting of beds of gravel, clay, incoherent sand, or friable sandstone, but this character is not constant; for there are some tertiary strata, particularly of limestone, which are as solid as any of the secondary rocks; and Mr. Lyell has pointed out many instances of tertiary beds possessing the mineral characters which were at one time considered peculiar characteristics of older strata.

The difference between the organic remains of the secondary and tertiary epochs is still more decided. No species of shells is known common to the cretaceous group and the oldest members of the tertiary class.

Even many of the genera are widely different; chambered univalves belonging to cephalopodous molluscs of the genera Nautilus, Ammonites, Scaphites, and Bacculites, which prevailed in the oolitic and cretaceous systems, are replaced in the tertiary formations by gasteropoda of the genera Cypræa, Conus, Voluta, Strombus, Murex, Fusus, Cerithium, Mitra, and Pleurotoma, genera which, in the existing seas, are the richest in species.

According to the recent researches of M. Agassiz, the fossil fishes of the tertiary era are equally characteristic. During the cretaceous epoch a great change had taken place in the organization of fishes. Of the four orders under which he has arranged this class of the animal kingdom, the placoïdians and ganoïdians had prevailed exclusively till the termination of the oolitic system, when they suddenly ceased, and the ctenoïdians and cycloïdians, which comprise the majority of existing genera, made their appearance with the commencement of the cretaceous system.

A large portion of the genera of these new orders expired with the *chalk*. New genera were introduced, during the tertiary era, approaching more to the characters of living fishes; but not a single tertiary species has been obtained identical with any now living; and the greater part of the European fishes of that era resemble forms now confined to the tropics.

The supracretaceous strata are further distinguished by the absence of those strange and gigantic saurian forms to which we have before alluded as flourishing during the oolitic period; for the tertiary saurians differed but little from existing crocodiles and alligators.

The only remains of mammalia which have as yet been discovered, in any formation below the tertiary system, are a few remains of a small marsupial animal found high in the oolitic system, in the calcareous slate of Stonesfield in Oxfordshire, and confined to that locality. In the tertiary marine beds the remains of cetacea, or marine mammalia, are first met with, and some of the deposits of the same era abound in the remains of large terrestrial mammalia.

The tertiary strata are likewise distinguished from the secondary by the circumstances under which they appear to have been formed. From the secondary strata occurring in large sheets of rock, continuous over extensive area, it would appear that while they were deposited, a great ocean prevailed over most of the northern hemisphere; but the tertiary strata were formed after the European seas became divided into gulfs, lagoons, and estuaries, of limited extent, but frequently of great depth. Strata occur in which land and fresh-water shells, drifted wood, and the remains of terrestrial mammalia, are mingled in such a manner as to indicate their formation in estuaries, into which large rivers flowed; and in many cases there are such alternations of marine and fluviatile deposits as to show that the land, during this period, was elevated and submerged more than once. The numerous deposits which contain exclusively terrestrial remains and fresh-water shells and fishes, show that the continents and large islands of the tertiary epoch were extensively covered by lakes.

Thus, by mineral and zoological characters, and by the mode of their occurrence, the tertiary formations are, as a group, well-defined and easily distinguished from the secondary strata; but the local and independent character of these insulated deposits renders it extremely difficult to form them into a chronological series; since the cases are rare in which one set of tertiary beds overlap another, so as to determine their different ages by the evidence of superposition; and their mineral characters are of less value for the discrimination of different members of the system than in the case of the secondary strata; clay-sand and gravel are but the detritus of argillaceous, calcareous, and siliceous rocks, more or less finely comminuted. If, then, we suppose three different contemporaneous seas of limited extent, bounded, one by quartzose or granite rocks, another by argillaceous schistus, and a third by limestone, it is evident that on the beds of these seas being laid dry, strata of sand would prevail in that deposit which was bounded by quartzose rocks, clay where the bounding rocks were argillaceous, and marl where the limestone was sufficiently abundant in the neighbourhood to afford a considerable portion of calcareous matter; or if three rivers charged, one with siliceous, another with calcareous, and a third with argillaceous sediment, should enter the same gulf or inland sea, deposits of these different characters would prevail in the vicinity of the different rivers, and would occasionally alternate with one another, as one river or the other happened to be in flood when the waters of the others were comparatively low; and the whole would produce a complete contemporaneous formation of different mineral characters, in which it would not be very easy to establish any precise order of superposition, almost every different section affording a different series of strata. The nature of the deposits would also be influenced by the velocity of the currents transporting detritus, and the distance to which it was borne. Gravel would be deposited near the shores, and where rapid rivers entered the still water, sand would be borne further, and marls composed of the most-finely comminuted matter would be transported to the greatest distance, and slowly deposited in the deepest parts. These mechanical deposits would be further modified by the admixture of waters of springs holding calcareous and siliceous matter in solution, which would precipitate calcareous tuffs and travertins, and beds of siliceous rock. Thus the mineral characters of the tertiary strata may be relied on as indications of the sources from which they were derived, and of the circumstances under which they were formed, but not as indications of the epoch of their formation. It is chiefly, therefore, upon organic remains that we must rely in determining the relative ages of different members of the tertiary series. Regarding testacea as of the most general distribution, and considering the remains of plants and vertebrated animals as consisting of too few species, and confined to too few localities, Mr. Lyell has arranged the tertiary strata under four divisions, according to the proportional quantity of shells of existing species found in them in a fossil state.

To these divisions he has given the names of the pliocene (newer and older), the miocene, and the eocene. These names are formed by compounding the Greek word *καινος*, *recent*, with *πλειων*, *more*, or *majority*, *μειων*, *less*, or *minority*, and *εως*, the *dawn;* thus indicating that the older tertiary strata only manifest the dawn or commencement of existing races—that in the middle or pliocene group these, though more numerous than in the eocene, constitute the minority,—and that in the pliocene, or most modern, they form the majority over extinct species.

The total number of fossil shells known in the tertiary strata are 3036; of these, 777 are found in the pliocene, 1021 in the miocene, and 1238 in the eocene.

The newer pliocene strata contain	90 to 95	per cent. of *recent* species.
The older pliocene . . .	35 to 50	
The miocene	18	
The eocene	3½ to 5	

NEWER PLIOCENE.

To this epoch belong the limestones, sandstones, and marls, alternating with volcanic beds in the Val di Noto, in the southern extremity of Sicily, and constituting hills from one to two thousand feet above the level of the sea. They contain shells, nearly the whole of which belong to species now inhabiting the Mediterranean; and there is decisive evidence that the alternating lavas have resulted from numerous submarine eruptions repeated at successive intervals during the formation of the subaqueous strata. They may be divided into the three following groups in the descending order.

1. Great limestone formation,—a yellowish-white calcareous rock of variable character, sometimes resembling the calcaire grossier of the Paris basin. It often contains the leaves of plants and reeds, as if a stream of fresh water holding carbonate of lime in solution, and floating down terrestrial vegetable remains, had flowed into the sea in the neighbourhood. It is sometimes more compact, resembling a precipitate from the waters of mineral springs. The thickness of the limestone is 700 or 800 feet. The thickness of the inferior groups to be next described is much less.

2. Schistose and arenaceous limestone, approaching the character of a calcareous conglomerate, sometimes tending to a pisolitic and oolitic structure.

3. Blue marls, called in Sicily *creta*, inclosing shells in a beautiful state of preservation. The order of position of these three groups is exhibited at Castrogiovanni, where the limestone of the Val di Noto is seen passing downwards into a calcareous sandstone, reposing on the marls which rest upon another series of marls containing gypsum in some parts of Sicily, and abounding in sulphur and salt.

The age of these gypsums and sulphureous marls is not yet determined; but Mr. Lyell supposes it to be of an older tertiary epoch than the newer pliocene. The base of Etna, to the height of from 800 to 1000 feet, is composed of alternations of volcanic rocks, marls, and sands of the third group; the marine strata sometimes extend to the thickness of 300 feet without any intermixture of volcanic matter. These are covered by some of the modern lavas of Etna, but there are no sections to prove that the whole cone of Etna has accumulated since the formation of the pliocene strata. In the Cyclopean Isles, a cluster of rocks to the north of Catania, where similar alternations of marine and volcanic rocks occur, the marls are much hardened and converted into siliceous schist, the lamination exhibiting contortions as irregular as those of some of the primary schists.

To this epoch Mr. Lyell also refers the lacustrine formations of the valley of the Elsa, between Florence and Sienna, where lacustrine strata and travertin, several hundred feet deep, containing shells belonging to species now inhabiting the rivers and lakes of Italy, repose on marine marls and shells belonging to the older pliocene era. The travertins and tufas which cap the hills of Rome, and the Loess of the Valley of the Rhine, a calcareous loam containing land and fresh-water shells,—all of existing species,—are placed by him in the newer pliocene era.

OLDER PLIOCENE.

THE English crag, the Subappenine sands and marls of Tuscany and Northern Italy, also the beds of marl and gravel at the foot of the Maritime Alps near Genoa, the tertiary strata at the eastern extremity of the Pyrenees, in the South of France, and at Malaga and Grenada in Spain, and the tertiaries of the Morea, are all referred to this epoch by M. Deshayes and Mr. Lyell, because they contain the same proportion of existing species of shells. The European mammalian remains of the pliocene era consist of existing genera, but of species extinct or no longer inhabiting Europe, such as the elephant, hippopotamus, rhinoceros, together with the mastodon, an extinct genus allied to the elephant. Dr. Buckland says that this is the oldest formation in which Ruminantia—oxen and deer—are abundantly found, and that it is also distinguished by the increased abundance of Rodentia and Carnivora. Those extinct genera of Pachydermata, which we shall see flourished exclusively during the eocene period, are not found in pliocene strata, while mixtures of the eocene and pliocene mammalia are found in the strata of the miocene era. The mammiferous remains of the pliocene and miocene periods are found under the following conditions:—

1. Drifted into seas and estuaries, accompanied by marine shells, and sometimes covered with Balarii and Flustra, showing that they had remained some time as bones at the bottom of the sea.

2. They occur in lacustrine and fluviatile deposits, mixed with land and fresh-water shells, as at North Cliff, near Market Weighton, in Yorkshire; at Brentford, Stratford, and other places in the Valley of the Thames; and many other localities in England and on the Continent.

3. Mammalian remains occur in caverns and fissures of rocks, such as the celebrated cave at Kirkdale, in Yorkshire, described by Dr. Buckland, which appears to have long been inhabited by hyenas, who had dragged in for food the bones of the larger animals. Into others, as the bear caverns of Franconia, the animals may have merely retired to die.

4. Grazing quadrupeds have fallen into open fissures, and their bones, accumulating during a long period, and mixed with debris of the rock, have been cemented by the infiltration of carbonate of lime into osseous breccias, such as that of Nice, Gibraltar, and the Mendip Hills. These open fissures have, in many cases, been the means by which bones have been introduced into caverns, currents of water carrying them forward, and lodging them, with pebbles and silt, wherever there was a hollow in the floor of the cavern.

These osseous caverns and fissures occur in great abundance in almost every part of the world. There are many instances of them in the cavernous limestone of England and Ireland, in the south and south-east of France, in the Ardennes, the Hartz, Franconia, Wirtemberg, Switzerland, Gibraltar, Italy, Sicily, and Greece. They have also been found in America, India, and Australia. The bones found in Australia are referred by Mr. Clifft to the kangaroo, wombat, dasyurus, kaola, and phalangista, most of them species now inhabiting that country. Three or four species were unknown to zoologists, and one, larger than the rest, was supposed by Mr. Clifft to belong to the hippopotamos.

5. Remains of terrestrial mammalia are found in accumulations of alluvial gravel covered by the lavas of volcanoes. The remains of mammalia of the miocene period are so entombed under some of the lavas of Central France, which commenced their action during the eocene epoch.

6. A sixth condition under which mammalian remains occur, is mixed with marine shells, all of existing species, and boulders drifted from the north. A tooth of the elephant was lately found under such circumstances in Cheshire, and is now in the possession of Sir Philip Egerton; *and remains of* elephants, stags, &c., have been discovered in the same

kind of northern drift, provincially "Till," in the south-east of Scotland. Some geologists deny the existence of an erratic block period, and consider these cases to be identical with the fourth condition, viz., that of carcases drifted into the sea by rivers; and this is the explanation offered by Mr. Murchison, of the case of bones of mammalia accompanied by fluviatile and lucustrine shells at Cropthorne, in Worcestershire, and covered by the northern drift, which, according to his hypothesis, was a gradual accumulation in a strait that, up to a very recent epoch, divided Wales from "England Proper," the Cotswolds forming its eastern boundary*. We alluded in our last Number to the evidence required to decide the question, whether this northern drift had not passed over land as well as sea.

The seas of the pliocene era, and also of the miocene, were inhabited by marine mammalia, consisting of whales, dolphins, seals, the walrus, and the lamantin, or manati, the existing species of which last genus are confined to the tropics.

The Crag. The only English tertiary formation of the older pliocene era is called the Crag, a provincial name for gravel. It occupies the low grounds along the coasts of Norfolk, Suffolk, and Essex, resting sometimes on the chalk, in other cases on the London clay. The most recent information respecting the crag is derived from the observations of Mr. Charlesworth, who considers that it consists of two well-defined beds, the upper characterized by its ferruginous colour, the lower by the presence of corals; and he proposes for them the names of the "red crag," and the "coralline crag." These beds are best seen at Ramsholt, on the eastern bank of the Deben, at Tattingstone, between the Orwell and Stour, Sudbourn Park, twenty miles to the east of Tattingstone, and Orford.

The red crag varies in thickness from four to nine feet, the coralline crag from seven to twelve. The latter deposit consists of white calcareous sand, and contains many shells which do not appear to have been rolled, and the species often occur in groups. The corals are most abundant at Orford and Sudbourn. From the two deposits have been obtained the following species:—annulata, 13; conchifera, 189; cirripeda, 11; mollusca, 257. The mollusca include 50 species of minute cephalopoda. Of the above species, 80 are considered by Mr. Charlesworth peculiar to the red crag, 280 to the coralline crag, and the remaining 150 are common to the two deposits. The *Fusus Contrarius*, and the Buccina and Murices, so common in the red crag, are wanting in the coralline crag. The former contains teeth of fishes, in the latter they are rare. The remains of mammalia appears confined to the upper beds. Mr. Charlesworth concludes that these deposits were formed under different conditions, and at different epochs. In commenting on these facts, in his address from the chair of the Geological Society, Mr. Lyell admits the former conclusion, but denies the latter. Referring to an opinion of Mr. Charlesworth, that of the 150 species common to the two deposits, many may have belonged to the lower bed and been washed into the newer one, Mr. Lyell observes, "Such accidental mixtures have doubtless occurred, and they have been occasionally remarked by geologists in other places, under similar circumstances, but I continue to believe that these upper and lower divisions of the crag should be referred to the same geological epoch. The determination of that period, or of the exact place which the crag should occupy in the chronological series of European strata, is a more difficult question. When I first submitted 111 species of crag shells to the examination of M. Deshayes, he was of opinion that 66 of them were extinct, and that the others belonged to recent species now inhabitants of the German ocean. I lately laid before him 60 species from the coralline crag with which Mr. Charlesworth has favoured me, and he was still of opinion that the proportion of recent species was equally great.

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* *Proceedings of the Geological Society*, vol. ii. p. 334.

"But I should add, that the suites of individuals of each species were not so full and complete as might have been desired, to enable these identifications to be placed beyond all doubt. Dr. Beck has lately seen 260 species of crag shells in Mr. Charlesworth's cabinet in London, and informs me, that, although a large proportion of the species approach very near to others which now live in our northern seas, he regards them as almost all of distinct species, and unknown as living. Both he and M. Deshayes have declared the shells to be those of a northern climate, and, according to Dr. Beck, the climate may even have resembled that of our arctic regions."

In regard to the discordance in the results at which these eminent conchologists have arrived, it may arise not only from the unequal opportunities which they have enjoyed of examining the necessary data, but also, in part, from the different estimate which they have formed of the amount of variation necessary to constitute a distinct species. One example will sufficiently illustrate my meaning. Those naturalists who agree with M. Deshayes, in referring all the living varieties of *Lucina divaricata* brought from different countries to be one and the same species, will identify many more fossils with recent shells than those who agree with Dr. Beck in dividing the same recent individuals of *Lucina divaricata* into six or eight distinct species. Provided, however, each zoologist is consistent with himself, and provided the distinctive characters relied on as specific by each, are commensurate one with another, no confusion will arise*. We may add that, while M. Deshayes and Dr. Beck both consider the shells of the crag as those of a northern climate, and while the latter zoologist even discovers in them a resemblance to shells of arctic seas, Agassiz pronounces its fishes, as far as they are yet known, to be all of extinct species, belonging to genera now inhabiting the tropics. The fresh-water formation of Aix, in Provence, which, on the evidence of its shells, Mr. Lyell classes among the eocene strata; and the lacustrine formation of Œnengen, which some geologists considered as the most modern known tertiary deposit, have been identified by M. Agassiz, by means of their fossil fishes, with the molasse of Switzerland classed by Lyell with the miocene strata.

It is probable that fossil ichthyology, will, before long, throw much light on the chronological arrangement of the tertiary strata. In fossil fishes, we have the remains of animals of a higher organization than molluscs, and furnished with other solid parts than a mere testaceous covering, pervading all the strata, from the oldest to the most recent, and the changes of genera and species from one formation to another, do not take place insensibly, like those of molluscs, but abruptly. A tooth, or a scale is often sufficient to establish, not only the order and genus, but even the species of the fish to which it belonged.

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* *Proceedings of the Geological Society*, vol. ii. p. 373.

The best tests of the correctness of the principles on which the classification of Agassiz is founded, are, that it yields consistent results through the whole series of living and fossil fishes; and that when, from the examination of a mutilated specimen, possessing only scales of an unknown fish, without either head, tail, or fins, he has sketched a restoration of its form, subsequent discoveries of the entire animal have verified his predictions as to its organization. In recent as well as fossil shells, we have merely the external covering constructed by an animal without any solid parts. The animal belonging to shells of living species is often unknown to us; and we only deduce its structure from analogy. On this, to a certain extent, we may safely rely. Knowing the organization of an animal inhabiting a shell of a certain general form, we may conclude that a shell of a similar form was inhabited by an animal of a similar general structure. On this evidence, we consider that all chambered univalves, like the Nautilus, belonged to cephalopodous * molluscs; and we infer that all shells having a canal or notch at the base, like the common Whelk (*Buccinum undatum*), belonged to carnivorous trachelopoda †; furnished with a retractile proboscis, for the purpose of boring into other shells. But when we descend to minor differences, it can scarcely be contended that those minute distinctions in the form, thickness, colour, or markings of shells, which constitute the specific differences of some conchologists, must necessarily have been accompanied by such differences in the organization of the animal, as would, without reference to the shell, have been sufficient to constitute a distinct species.

Some of the modifications of colour, size, thickness, &c., may have originated in difference of age, climate, and food, occasioning differences in the quantities of carbonate of lime secreted for the formation of the shell. With respect to age, it is certain, that in some genera, it occasions great dissimilarity in the form—for what can be more unlike, than the testaceous coverings of young and adult individuals of some species of the genera of the Cypræa and Ovula.

We must also be upon our guard against falling into serious errors in fixing the date of these modern formations, from the proportional quantity of *unknown* shells which they contain, while our knowledge of the testacea inhabiting the seas which wash the shores of our own island is so very limited. That northern drift to which we have before alluded, as extensively distributed over Lancashire, Cheshire, and Shropshire, contains fragments of marine shells. Mr. Murchison has obtained from it many species, which have been examined by some good conchologists, including Dr. Beck, of Copenhagen, prove to be identical with species now inhabiting adjacent seas. A similar accumulation occurs in the south of Scotland, known by the local name of "Till," containing, according to Mr. Smith, of Jordan Hill, near Glasgow, broken marine shells, and occasionally, though rarely, stag's horns and tusks, and bones of the elephant. This tumultuous deposit is covered in several places, some eight miles from the sea, and forty feet above its level, by a tranquil deposit of finely laminated clay, containing bones of fishes and sea-fowl, fragments of sea-weeds, crab's claws, and numerous layers of shells, the greater number of which were of the species abounding in the present seas, while some of the species had become very rare, if not extinct, with reference to Scotland. On this evidence we have heard it contended that the tumultuous deposits of Scotland and Shropshire could not be contemporaneous, because the latter contained only the remains of species inhabiting adjacent seas, while the former contained a per-centage of extinct or unknown shells *.

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* Cephalopoda, having the organs of motion attached to the head, and consequently moving at the bottom of the sea, with the head downwards.

† Trachelopoda, having the foot attached to the neck, or anterior part of the body, as in the garden snail.

On the same evidence, it might be contended that the deposits now forming in the Scotch seas, are older than the shelly gravel now lying high and dry in the centre of England, for we have been informed by Mr. Smith, that on dredging at a little distance from the mouth of the Clyde, he brought up several species of shells that were unknown to conchologists.

MIOCENE STRATA.

To this epoch belong the Faluns of the Loire; the Basin of the Gironde, or deposits of Bourdeaux and Dax; the tertiary strata of Montpellier; those of the hills of Mont Ferrat, and the Superga; the Molasse of Switzerland; the deposits of Lower Styria and Vienna, on the Basin of the Danube; the deposits of Volhynia and Podolia; the basin of the Rhine, near Mayence; the lacustrine strata of Epplesheim, in Hesse Darmstadt, and Georgesgemund, in Bavaria.

Faluns of the Loire.—This deposit is of slight thickness, resembling the English red crag in mineral composition, and containing marine shells, mixed with mammiferous remains, and sometimes incrusted with Flustra, Serpulæ, and Balani, thus indicating a littoral deposit.

M. Desoryers referred it to the age of the English crag, because of the similarity in mineral character, and because it rests on the upper lacustrine formations of the Paris basin, which are continuous over a platform between the Seine and the Loire, in the same manner that the crag rests on the London clay, the equivalent of one of the members of the Paris basin. Mr. Lyell, and M. Deshayes, however, on account of the proportional quantity of recent species obtained from it, make it of an intermediate age, between the crag and the deposits of the Paris basin; and evidence of the mammalian remains seems also to indicate a difference in the epochs of the crag and Faluns; for in the Faluns and certain groups of the same age, which occur not far to the west of Orleans, remains of Palæotherium magnum have been found, a species of the Paris basin; accompanied by Mastodon angustideus, Hippopotamus major, H. minutus, Rhinoceros leptorhinus, and R. minutus, Tapir gigas; a small species of Anthracotherium, Sus, Equus (a small species), Cervus, and an undetermined species of Rodentia, and similar mixtures of the extinct genera of the lacustrine eocene mammalia, with th earliest forms of existing genera, have been found at Georgensgemund in Bavaria, and at Epplesheim, near Hesse Darmstadt.

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* *Proceedings of the Geological Society*, vol. ii. p. 428.

In this latter locality occurs the Dinotherium, the largest of known terrestrial mammalia. It appears to hold an intermediate place between the Tapirs and the Mastodon. The scapula, or shoulder blade, resembles more nearly that of the mole than any other animal, and implies an adaptation of the fore-leg to the purpose of digging, an inference which is confirmed by the singular structure of the lower jaw. In the character of its molar teeth, it is nearly allied to the tapirs, but it differs from them, and indeed from all other known quadrupeds, in having two great tusks at the anterior extremity of the lower jaw, curved downwards, like those in the upper jaw of the walrus.

From the inconvenience so bulky an animal, possessing jaws-four feet long, armed with such enormous tusks, must have experienced on the dry land, and from the aquatic habits of the tapirs, to which it appears allied, Dr. Buckland supposes that it lived chiefly in fresh-water lakes; and that the tusks were employed in grubbing up the roots of large aquatic vegetables from the bottom, in which service they would combine the mechanical powers of the pickaxe with those of the horse-hoe, the great weight of the head assisting the operation; these tusks might also have been applied to moor the head of the animal to the bank, as it slept submerged, with its nostrils only above the water; and they might also have been used, like those of the walrus, for the purpose of dragging the body out of the water, and also as weapons of defence.

From its near approximation to the living tapir, he also inferred that it was furnished with a proboscis, by means of which it conveyed to its mouth the vegetables raked up from the bottom by its tusks and claws; and from an ungual bone found with some other remains of Dinotherium, having a remarkable bifurcation, not known in any other quadruped except the Pangolins, he inferred that it was furnished with a claw possessing peculiar advantages for scraping and digging, and thus indicating functions concurrent with those of the tusks and scapula.

Since the publication of the first edition of the *Bridgewater Treatise*, in which these views were advanced, a nearly entire head has been found by Professor Kaup: the width of the anterior portion of the skull, and the deep depression there visible, seem favourable to the supposition of its being furnished with a proboscis; and Professor Kaup and Dr. Klipstein, who have described and figured the skull, consider Dr. Buckland's conjectures, as to the aquatic habits of the animal, confirmed by the approximation in the form of the occipital bone to the occiput of cetacea, the Dinotherium in this structure affording new and important links between the Cetacea and Pachydermata. M. de Blainville, and some other French naturalists, even consider it to have belonged to the cetaceous order, and the family of the Dugongs and Lamantins.

BASIN OF THE GIRONDE, DISTRICT OF BOURDEAUX AND DAX.

THERE is a great extent of tertiary strata between the Gironde and the Pyrenees. They are variable in their mineral character, but admit of an arrangement into four groups, their united thickness being, in some instances very considerable, in others, the secondary rocks being scarcely concealed by a thin covering of tertiary strata.

These groups in the neighbourhood of Dax are, in the descending order: 1. Siliceous sand, without shells; 2. Gravel; 3. Sand and marl, with shells; 4. Blue marl, with shells. The shells are of the same zoological character as those of the Basin of the Loire. There is often an intermixture of fluviatile shells with the marine, indicating an estuary deposit.

At Saucats, near Bourdeaux, is a fresh-water limestone, of considerable thickness, perforated on its upper surface by marine shells, chiefly of extinct species: thus affording evidence that the spot has been occupied alternately by salt and fresh water.

Mr. Lyell describes an inland cliff near Dax, about twelve miles from the sea, at the base of which is a ledge of clay, composing one of the lower members of the series, the rest having been denuded. Between the movements which elevated the tertiary strata to their present height, a pause must have intervened, which allowed the sea to advance and strip off some of the upper beds.

The tertiary series of the basin of the Gironde rest in general on secondary rocks, but between Blaye and La Roche they are stated by Mr. Lyell to be superimposed on limestone, from one hundred to two hundred feet thick, resembling the calcaire grossier of the Paris basin, and containing many species identical with the shells of that formation.

Montpellier.—These deposits are classed by Mr. Lyell with those of the miocene epoch, because they contain many of the Bourdeaux and Dax species of shells; although the catalogue of M. Marcel de Serres enumerates many pliocene species. The mammalian remains appear to be those of the miocene era,—Mastodon angustideus, Rhinoceros leptorhinus, or a tapir, a Palæotherium, and an Anthracotherium.

Piedmont.—The hill of Superga, near Turin, and the chain of Mont Ferrat, in the basin of the Bormida, consists of highly-inclined strata of green sand and marl, coarse conglomerate forming the lower part of the mass; shells referrable to the miocene era occur in the green sand. Nearly horizontal marls, containing shells of the older pliocene strata, are seen in various places near Turin. The country has not yet been sufficiently examined to obtain sections illustrative of the position of the miocene and older pliocene strata, but it has been ascertained that the highly-inclined green sand, which is in contact with the primary strata, is the oldest part of the series.

Molasse of Switzerland.—At the northern base of the Alps, on the side of Savoy, and throughout the lower part of Switzerland, a soft green sandstone occurs, called "molasse," much resembling some of the beds of the basin of the Bormida, and associated, like them, with marl and conglomerates. It contains but few shells, but some found near Lucerne are referred to this epoch.

BASINS OF VIENNA AND LOWER STYRIA.

Of all the tertiary groups of Europe, this is, perhaps, the most important in point of thickness and geographical extent, though others have obtained more celebrity, from the nature of their organic contents, and from some of the most interesting investigations of modern geology being connected with them. The Styrian beds, described by Mr. Murchison and Professor Sedgwick, exhibit nearly the same phenomena as those of Vienna, and are divisible into three groups, in position nearly horizontal, but having a slight dip towards the east. They appear to have been formed in an inland sea, which once filled the basin of Hungary, and extended to the foot of the eastern termination of the Alps; the Vienna strata having been formed in another bay of the same sea, separated by a great promontory connected with the central ridge of the Alps. The Styrian tertiary strata, near their western termination among the older and more elevated formations, fill an irregular trough-shaped depression, through which the waters of the Mar, the Draab, and the Drave, make their way to the lower Danube. From this region they gradually expand into the plains of Hungary.

We have already said that they may be divided into three groups, the first occupying the broken region extending from the neighbourhood of Eibeswald, and the eastern skirts of the Schwanberg Alp, to the banks of the Mur. The first, or lowest group, consists of alternating beds of shale and sandstone, with marl and sand, some of the marls containing many marine shells. Near the protuberances of secondary rocks, are masses of conglomerate, containing rounded silicious pebbles, and resembling the shingle of a beach. This group is referred, by Professor Sedgwick and Mr. Murchison, to the age of the Paris basin; but Mr. Lyell contends that though some of the shells mentioned by them are common to the Paris basin, such a coincidence holds true with regard to all the miocene formations of Europe, and that, associated with them, are some characteristic miocene fossils.

The second principal group is finely exposed in the escarpments of Wildon, and in the hills of Ehrenhausen, on the right bank of the Mur. It is characterized by coralline and concretionary limestone, of a yellowish-white colour. The upper beds of this group occupy a considerable portion of the hilly region on the south side of the Mur, stretching nearly east and west. They consist of marls, sometimes so calcareous as to pass into irregular concretionary masses of white limestone,—of beds of shale, and of sand and sandstone, occasionally so coarse as almost to pass into the form of a conglomerate. The coralline limestone is in some places four hundred feet thick, and affords an instance of a tertiary coralline limestone, more largely developed than the secondary coral rag of England. This group is unanimously admitted to belong to the miocene epoch.

The third group consists of marl and sandstone, abounds in fossils, and contains beds of coarse calcareous sandstone. The authors include in it the yellowish micaceous sands, with bands of sandy marl, and occasionally beds of small pebbles, which occupy a large portion of the surface of the country near the frontiers of Styria and Hungary. They contain the bones of several species of mammalia. Professor Sedgwick and Mr. Murchison class this group with the younger deposits of the Subappennine regions, that is, with the pliocene era. Mr. Lyell is of opinion, that its fossils do not depart so widely from the miocene type, as to authorize their separation.

The deposits of the Vienna basin are in the same horizontal or slightly inclined position, and exhibit very nearly the same phenomena as those of Lower Styria.

Owing to their slight inclination, the lowest tertiary groups of Vienna are very little known, having only been reached by boring for water, and other artificial excavations. Professor Sedgwick and Mr. Murchison give the following synopsis of the successive deposits in the neighbourhood of Vienna, on the authority of M. Partsch, some of the facts having been verified by their own observations. The section is in the descending order*.

1. Alluvial loam, called Löss, with terrestrial shells of existing species mixed with bones of extinct elephants; average thickness, 60 feet, in some places much more	60 ft.
2. Gravel and sand, with subordinate concretionary calcareous masses, sometimes oolitic. It contains the bones of mastodon, anthracotherium, tapir, &c.	70
3. Freshwater limestone, only in patches, containing planorbes and helices	140
4. Great white coral limestone, containing large pectens and echini, also bones of the tapir, mastodon, stag, and other mammalia	150
5. Coarse calcareous conglomerate breccia, and calcareous grit, forming the base of the white coral limestone of the Leitha Gebirge	200
6. Superior blue marl (Tegel) with a profusion of fossils	40
7. Yellow-sand, with calcareous grits, and many fossils. *Cerethium pictum*, and two or three species of ostrea, abound in it	120
8. Inferior blue marl (Tegel), only known by borings, and some partial excavations; fossils, therefore, little known	300
9. White sands, &c., reached only by boring; thickness, therefore, entirely unknown	
	1080

Volhynia and Podolia.—In this district, bounded by Gallicia on the west, and the Ukraine on the east, and comprising parts of the basins of the Don and Dniester, there is a great accumulation of sand, sandstone, clay, coarse limestone, and a white oolitic limestone, the last of considerable thickness. The marine shells derived from these deposits have been pronounced by Deshayes to belong to the miocene era.

Mayence.—The tertiary strata of Mayence extend along the left bank of the Rhine, from Mayence to the neighbourhood of Manheim, and recur near Frankfort. From the abundance of shells of the genera Cerithiam, and the quantities of land shells contained in them, they appear to have been formed in an estuary fed by rivers. The sandy beds of Epplesheim, in which the remains of Dinotherium are found, have been already mentioned as belonging to the miocene era.

EOCENE STRATA.

TERTIARY FORMATIONS OF THE PARIS BASIN.—LACUSTRINE FORMATIONS OF AUVERGNE.—BASINS OF LONDON AND HAMPSHIRE.

THE strata of the eocene epoch were the first tertiary deposits that attracted the attention of geologists. Before the strata of the Paris basin had been investigated by Cuvier and Brogniart, the tertiary formations were passed over as mere superficial sand and gravel unworthy of notice, and yet they afford some of the most interesting phenomena of geology; they occupy a large portion of the surface of the present dry land; they throw great light on the distribution of land and water during an epoch which, in geological chronology, is comparatively recent; they furnish us with an assemblage of animals and plants more varied and extensive than that derived from the secondary formations, and approaching more the character of those with which we are contemporary; they astonish and delight us by the instances they afford of the many curious variations in that great plan of organic mechanism which has prevailed from the earliest epochs in which we can trace any signs of the existence of animal and vegetable life. By the evidence they afford of the slow progress by which even these comparatively modern deposits have been elaborated, they furnish us with proofs of the long lapse of ages employed in bringing the earth into its present condition; they draw our attention to a state of things approaching that amidst which we ourselves live, and to changes such as are slowly taking place around us; and thus they teach us, in our speculations on the past, to advance from the known to the unknown, and to endeavour to account for ancient changes on the earth's surface, as much as possible by the operation of causes now in action, only having recourse to unknown causes for the explanation of residuary phenomena, which it is clear could not have been produced by existing forces, however long their action might have been continued.

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* *Transactions of the Geological Society*, New Series, vol. iii., part 2, p. 403.

The formations of the Paris basin consist of several alternations of marine with fresh-water strata, from the latter of which have been derived innumerable bones of mammalia of extinct genera and species. For the reconstruction of the skeletons of unknown animals, we are indebted to the sagacity of Cuvier, and his profound anatomical knowledge. He has described in elegant language the exciting interest experienced by him while occupied in this great work, and has at the same time explained the principles upon which it proceeded. "Placed," he says, "in the midst of a great charnel-house, surrounded by mutilated fragments of many hundred skeletons of more than twenty kinds of animals, piled confusedly around me, the task assigned me was to restore them all to their original position. At the voice of comparative anatomy, every bone, and fragment of a bone, resumed its place. I cannot find words to express the pleasure I experienced in seeing, as I discovered one character, how all the consequences which I had predicted from it were successively confirmed. The feet were found in accordance with the characters announced by the teeth,—the teeth in harmony with those indicated before-hand by the feet; the bones of the legs and thighs, and every connecting portion of the extremities, were found set together precisely as I had arranged them before my conjectures were verified by the discovery of the parts entire[*]."

The result of these labours was the discovery in the Paris basin of nearly fifty extinct species of mammalia, most of which belonged to extinct genera of the order Pachydermata, which received the names of Palæotherium, Anaplotherium, Lophiodon, Anthracotherium, Cheropotamus, and Adapis.

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[*] *Ossemens Fossiles,* Introduction.

These extinct genera approached most nearly to the characters of the tapirs, which inhabit the warm marshy regions of South America and Africa; but they had other points of resemblance connecting them with the rhinoceros, hippopotamus, hog, and horse. The Adapis appears to have formed a link between the Pachydermata and the insectivorous carnivora. In form, it most nearly resembled a hedge-hog, but was three times the size of that animal. The order of Carnivora was represented by extinct animals of the genera to which belong the wolf, fox, bat; Coati, a genus now inhabiting the warm region of America, and the Genette, which now ranges from the South of Europe to the Cape of Good Hope.

Of the order Marsupialia there was a small didelphis, allied to the opossum of North and South America; of the order Rodentia, a dormouse and a squirrel; of birds, nine or ten species of the genera,—buzzard, owl, quail, woodcock, sea-lark (tringa), curlew, and pelican,—all referrible to four of the great orders, Accipitres, Gallinaceæ, Grallæ, and Palmipedes, out of the six into which the existing class of birds is divided. Even the eggs of aquatic birds have been preserved in the lacustrine formation of Auvergne.

Of reptiles, there were crocodiles and fresh-water tortoises, of the genera Emys and Triony; of fishes, Agassiz has determined seven extinct species of extinct genera.

The deposits of the Paris basin fill a depression in the chalk about 180 miles long, extending from north-east to south-west, and about 90 miles broad in its widest part. This depression appears to have been a gulf running deeply into the land, and opening towards the north into a sea, which at that epoch extended over a considerable portion of the North of Europe. In the course of their researches, Cuvier and Brogniart discovered that the strata above the chalk were not all marine, but that strata containing marine remains alternated with others containing land and fresh-water shells, and the bones of terrestrial quadrupeds; and thus they arrived at the same conclusion which had been attained by Smith from the examination of older strata in England, that there are certain fossils peculiar to certain strata. They grouped the beds above the chalk in the following order, beginning with the lowest.

1. First Fresh-water Formation .	Plastic Clay Lignite. First Sandstone.
2. First Marine Formation . .	Calcaire Grossier.
3. Second Fresh-water Formation	Siliceous Limestone. Gypsum with bones of Animals Fresh-water Marls.
4. Second Marine Formation . .	Gypseous Marine Marls. Upper Marine Sands, and Sandstones.
5. Third Fresh-water Formation .	Upper Marine Marls, and Limestone.

The following are the characters of these formations.—*Plastic clay*, so called because used in the potteries, of various colours,—white, grey, yellow, and red,—is of variable thickness, and rests sometimes on the chalk, sometimes on a layer of broken flints, or angular fragments of chalk cemented into a breccia. It contains lignites, amber, and shells, both fresh-water and marine.

Calcaire grossier. A coarse limestone, sufficiently hard to be used as a building stone. It is often separated from the plastic clay by a bed of sand. This formation is characterized by the abundance of its fossils, which are chiefly marine. Different groups of fossils are said to prevail in the upper, middle, and lower parts of the bed.

The greater part of the shells, characteristic of the Paris basin, are found in this formation imbedded in a calcareous sand, composed chiefly of broken shells,—land, fresh-water, and marine shells being mingled together. The marine shells, some of which may have lived on the spot, are characterized by the great proportion of species of Cerithium, a genus which inhabits estuaries near the mouths of rivers.

Siliceous Limestone, Calcaire siliceux.—A cellular limestone, sometimes white and soft, sometimes hard and compact, like a precipitate from mineral springs. It is penetrated by silex, unfiltrated in every direction. The sides of the cells are coated with mamillary concretions, or small transparent crystals of quartz.

Osseous Gypsum, and Marine Marls.—The gypseous rocks consist of an alternation of gypsum with white and green calcareous and argillaceous marls. Above this are thick beds of the same kind of marls, containing Lymneæ and Planorbes (fresh water shells), and prostrate trunks of palm trees. The gypseous strata contain the remains of the extinct genera of mammalia before enumerated. Above these, are marls containing marine shells, and among others, a bed of oysters, which are considered to have lived on the spot.

Upper Marine Sands and Sandstones.—These are composed of irregular beds of sandstone. In the lower portion, organic remains are very rare, and broken. These are succeeded in many places, by a limestone, sandstone, or calcareo-siliceous rock, abounding in marine remains of the genera Oliva, Fusus, Cerithium, Solarium, Melania, Pectunculus, Crassatella, Donax, Cytherea, Corbula, and Ostrea.

Upper Fresh-water formation. — Sometimes composed of white friable calcareous marls; others of different siliceous compounds, some of which are used as millstones. Sometimes it is destitute of shells, at others, Lymneæ, Planorbes, and Helices, abound in it together, with silicified wood, and the seeds of the chara, once considered fossil shells, and named Gyrogonites. Cuvier and Brogniart, supposed that these alternations had been occasioned by repeated irruptions and retreats of the ocean, and that these were the last strata deposited between the chalk and the present state of things; and that the bones of the elephant, rhinoceros, and hippopotamus were only found in superficial gravel, called diluvium, the formation of which was at that time attributed to a general and violent deluge within the historic era. Extensive generalization from local and insulated facts, are not unfrequent in the history of geology, and instances of them might be pointed out in other sciences, during the progress of their early career. They arise out of the eagerness of the mind to arrive at conclusions, and its impatience of unconnected details. We can scarcely be surprised that in the present case they were somewhat hastily adopted; and that, for a time, attempts were made to identify every tertiary formation, wherever found, with some member of the deposits of the Paris basin. These opinions, however, have yielded to a greater accumulation of facts. It now appears that the remains of elephants, which were supposed to be confined to the erratic block group, occur in numerous detached marine and lacustrine deposits, under such circumstances as to indicate gradual accumulation, and they have, in some situations, been found mixed with the remains of the extinct genera of the Paris basin; thus proving the existence of more than one tertiary epoch of long continuance, and indicating a gradual passage from one to the other.

It was further shown by M. Constant de Prevost, and other geologists, that not only the theories adopted by Cuvier and Brogniart, to account for the alternations of marine and fresh-water strata in the Paris basin required modification, but that the order of succession established by them for the different deposits, was only locally true, and that the formations 1, 2, 3, viz. the plastic clay, the calcaire grossier, the siliceous limestone, and ossiferous gypsum, instead of being successive deposits, were divisible into four nearly contemporaneous groups. The plastic clay, instead of being confined, as was at first supposed, to the lower part of the formation, alternates with the calcaire grossier; is repeated, with its fresh-water shells, in the very middle of that limestone, at Veaugerard, Bagneux, and other places, and is to be seen in a recent section near Paris, in the still higher parts of it. The calcaire siliceux, and the calcaire grossier, occupy distinct parts of the basin, the one being most largely developed, where the other is of slight thickness. They also alternate with each other towards the centre of the basin, as at Sergy and Osny. The gypsum, with its associated marls, which was supposed to be entirely subsequent to the calcaire grossier, and calcaire siliceux, alternates repeatedly in some places with the calcaire siliceux, and in others with the upper members of the calcaire grossier; and the gypsum and marls attain the greatest thickness where the two other groups are less fully developed. These circumstances seem to imply a gulf open towards the north, and fed by three rivers, the one charged with argillaceous sediment, the others holding in solution sulphate and carbonate of lime, and silica. With such solutions, the waters of rivers in volcanic countries, are often charged. The marine calcaire grossier is in greatest force towards the north, and the fresh-water calcaire siliceux towards the south. Towards the south, we shall presently see there existed during this epoch, a chain of lakes connected with extinct volcanoes, the drainage of which hydrographical basin might very easily have been into the gulf in which the Parisian strata were deposited; and we shall also see that the basins in which these ancient lakes existed, contain calcareous, siliceous, and gypseous strata, precisely similar to the fresh-water deposits of the Paris basin. In that basin, the gypseous deposit is most largely developed towards the centre, and M. Prevost, therefore, supposes it to have been precipitated from a river flowing from the east; on which Mr. Lyell observes, that "if the gypsum, and associated white and green marls of Montmartre were derived from a hydrographical basin distinct *from that of the* southern chain of lakes, this basin must nevertheless have been placed under circumstances extremely similar; for the identity of the rocks of Velay and Auvergne with the fresh-water group of Montmartre is such as can scarcely be appreciated by those geologists, who have not carefully examined the two countries*." Though the conditions above supposed, of an estuary fed by several rivers, appears to explain the alternations of the marine and fresh-water deposits, called by Cuvier the first and second fresh-water and the first marine formations, yet the products of the sea predominate exclusively during the second or upper marine group. It seems, therefore, necessary to have recourse to a subsidence of the land to account for the position of these marine sands, the lower parts of which contain only a few broken shells that appear to have been transported from a distance, and thus indicate the action of water, moving with sufficient velocity to transport sand, and to deposit it over a considerable space; after which, the cause which prevented the envelopment of organic remains ceased, and marine remains were imbedded in considerable quantity. The temporary and alternate prevalence in the estuary of the sea or a river, may have been occasioned by slight oscillations of the land; after which, a greater subsidence may have covered with sea a spot previously occupied by fresh water. Calcareous boulders, derived from the calcaire grossier, containing its peculiar fossils, and perforated by boring testacea, have been found in the upper marine sandstone; thus proving, that during the eocene period, the calcaire grossier in some part of the basin was exposed to denuding causes. To crown the whole, we have, on these marine deposits, the upper fresh-water formation, a deposit of marls and siliceous strata (such as we shall presently see were formed in some of the lakes we have before alluded to), containing plants, such as exist only on dry land, in fresh water, and in marshy places; and thus we have indications that after the estuary was silted up by the sands of the upper marine formation, a series of pools existed like those which frequently occupy the newest parts of a delta, and which were fed by springs holding siliceous matter in solution.

We will now proceed to the consideration of that group of lacustrine strata of the eocene epoch, lying to the south of the Paris basin, to which we have just alluded, as exhibiting many points of analogy with that formation, both in mineral composition and organic remains, and as tending to elucidate the circumstances under which it was formed. These deposits are situated in the districts of Auvergne, Velay, and Cantal. The largest of these ancient lacustrine basins is that of Auvergne, about one hundred miles long, and twenty broad, occupying the valley plain of the Allier above its junction with the Loire.

The boundaries of the ancient lake, which consist of primary rocks, are observable towards the south, east, and west, but not towards the north, where the local disturbances, of which there are abundant evidence in the inclined position of some of the strata, have removed all traces of them. The upper part of the Loire flows through the lacustrine district of Velay, and that of Cantal lies a little to the south-west of Auvergne. The same general characters pervade the fresh-water deposits of all these three districts; they may be divided into two groups, one consisting of gravel and arenaceous strata, the detritus of the neighbouring primary rocks, the other consisting of finely-laminated siliceous and calcareous marls, associated with limestone, and regular beds of silex, such as would be precipitated from springs charged with carbonate and sulphate of lime and silica.

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* *Lyell's Principles of Geology*, 4th ed., vol. iv., p. 185.

The coarser detrital matter is confined to the margins of the lakes, not always encircling them in a continuous band, but disposed in the form of those independent deltas observable where rapid streams enter the water of existing lakes. The finer detrital matters, namely the siliceous and calcareous marls, occupy the central parts of the basin, having the limestone, gypsum, and siliceous rock subordinate to them, and generally confined to their upper part.

This circumstance is of importance, as indicating thermal springs as the source whence these calcareous, siliceous, and gypseous strata were derived, for these deposits are precipitated most abundantly in those regions where volcanic forces are in activity, and these ancient lakes are connected with a system of extinct volcanoes, which it is evident had not come into action when the basins began to be filled with sedimentary deposits, because the gravel contains no pebbles of lava, and because, in the districts of Cantal and Velay, no traces of volcanic tuffs are found alternating with the fresh-water strata; while in the basin of Auvergne, a few partial alternations only are confined to the upper part of the series.

Not only do the gypseous and siliceous deposits of these lakes agree in mineral character with those of the Paris basin, but they have afforded bones of several mammiferous quadrupeds of the same genera as those which characterize the Paris basin, as also gyrogonites, or seed-vessels of the chara, and land and fresh-water shells, all of eocene species. Beneath the lavas of some of the extinct volcanoes of this district, are several accumulations of alluvium, at different heights above the river, containing bones of the elephant, mastodon, hippopotamus, rhinoceros, tapir, horse, boar, felis, hyæna, beaver, otter, hare, water-rat, deer, and ox, thus proving that volcanic action, which commenced on this spot during the eocene era, continued through the miocene, and perhaps a later period.

These lacustrine deposits afford some curious proofs of the slow and gradual process by which they were accumulated, and of the myriads of insects and molluscs which have contributed their exuviæ to the formation of rocks. The thickness of the green and white marls of Auvergne is in some places seven hundred feet. They are thinly laminated, the lamination being caused by numerous thin plates or scales of a small animal called cypris; some of the recent species of which abound in our stagnant pools and ditches. A form of limestone also occurs, called indusial, from its containing immense numbers of the indusiæ, or cases of the larvæ of Phryganeæ insects, the living species of which may also be observed in our ponds, and which have the power of fixing small fresh-water shells to the outside of their tubular cases. More than a hundred shells of a small species of Paludina have been counted on one tube of a large species of Phryanea, which abounds in the eocene lakes of Auvergne; and strata of indusial limestone, each six feet thick, which may be traced over a considerable area, are almost wholly composed of these tubes enveloped in travertin, so many as ten or twelve being packed within a cubic inch. In the foliated marls of the Cantal, the laminæ, to the depth of sixty feet, are so thin, that thirty are sometimes contained in the thickness of an inch, in each of which are preserved the flattened stems of the chara, or other plants, and sometimes numbers of small fresh-water shells.

We must not quit these lacustrine deposits, without observing that they afford several instances of tertiary strata, possessing all those mineral characters which were at one time considered sufficient to identify certain members of the secondary series.

Associated with the marls of Auvergne, and graduating upwards into strata containing eocene fossils, are strata undistinguishable from the new red sandstone of England. They appear to be derived from the detritus of the gneiss and mica schists of the primary strata bounding the tertiary basin, some of which decompose into a very similar soil.

An oolitic limestone occurs in another part of the basin, which bears a close resemblance to the Bath free-stone; but the most remarkable instance of the kind, is a fresh-water limestone undistinguishable by mineralogical characters from the chalk of England, and containing layers and nodules of flint, which appear to have separated from the matrix after the calcareous and siliceous matter had been blended, the limestone sometimes filling sinuous cavities in the flint, and the flinty nodules being often as irregular in their form as those of the English chalk. This fresh-water limestone lies upon the granite rocks, and as the true chalk sometimes occurs under similar circumstances, there is nothing in the order of superposition, which can enable us to decide the epoch of this formation. It is only by organic remains it can be shown to belong to the eocene era.

Instead of marine sponges, of the cretaceous epochs, the nodules of flint contain silicified seeds of the chara, a plant that grows at the bottom of fresh-water lakes, and instead of echini and marine testacea of the chalk, the fresh-water limestone contains lacustrine testacea identical, like the seed-vessels of the chara, with eocene species. These instances are valuable as lessons not to rely too implicitly on lithological characters in determining the age of rocks, and as pointing out thermal springs as one of the sources from which the cretaceous strata may have been derived.

The English equivalents of the strata of the Paris basin, are the London clay, the Bagshot sands, and the fresh-water strata of the Isle of Wight. The term basin, so commonly applied, though seldom with much propriety, to insulated tertiary formations, is particularly inapplicable to those supracretaceous districts known by the names of the London and Hampshire basins; because there is little doubt that although now separated by an intervening ridge of chalk, they are portions of a deposit which was once continuous.

The so-called basin of London derives its name from the subsoil of the neighbourhood of the English metropolis being composed of a blue clay containing marine remains analogous to those of the Paris basin. The London clay, in which term we include the lower part of the deposit generally separated from it under the name of the plastic clay, pies a large portion of the county of Suffolk, nearly the whole of

Essex, the whole of Middlesex, and portions of the counties of Berks, Surrey, and Kent.

The Hampshire basin extends along the coast from Brighton on the east, to near Pool on the west, its boundary ranging thence inland by Dorchester and Salisbury to Houghton Hill, its extreme point on the north, and thence south-east to its eastern termination at Brighton. It also comprises a large portion of the northern part of the Isle of Wight.

The strata of the Paris basin appear to have been deposited in a depression in the chalk previously formed by some movement of upheavement. The strata of the same epoch in England are conformable to the chalk, and have partaken of the movements to which it has been subject. Except in Alum Bay, where the London clay has been thrown into a vertical position, they deviate but slightly from the horizontal. From the occurrence of outlying masses of this formation, at a distance from the main body, and at considerable heights on the chalk, Dr. Buckland has concluded, not only that the strata of the London and Hampshire basins were once a continuous deposit, but even that it extended over the plains of Salisbury, Andover, and Basingstoke, and that it has been stripped of the chalk by denudation.

With respect to mineral character, the London clay may be described as a formation consisting of a series of clays above, and of sands and shingle below. This formation has been subdivided into the London clay and the plastic clay, the former name being applied to the upper parts of the series, the latter to the lower. This subdivision arose out of the opinion which prevailed after the description of the Parisian supracretaceous strata by Cuvier and Brogniart, that these strata formed the type to which all tertiary formations must be referred.

The attempt to establish an identity between the details of two contiguous groups like these, possessing the same zoological character, was more excusable than in some other cases where the intervening distances were greater and the analogies more remote. This subdivision of the London clay, however, is perfectly arbitrary; but if the subdivision had been necessary, nothing could be more unhappy than the name of *plastic clay*, applied to the lower part of the series, which consists, almost wholly, of beds of sands of various colours and of shingle, the clay only occurring in layers subordinate to the shingly and sandy masses.

The upper portion of the London clay is a tough bluish or blackish clay, sometimes slightly calcareous, rarely passing into a calcareous or siliceous sandstone, as at Bognor rocks, or into a stratified limestone, as in the cliff at Harwich. Concretions of argillaceous limestone, of an ovate form, traversed by intersecting fissures filled with calcareous spar and thence called Septaria, occur in the clay, both as detached nodules and in layers. Crystals of selenite are found in it, and most of its fossils are mineralized by sulphuret of iron. No bones of mammalia have been met with, but it contains remains of tortoises, crocodiles, crabs, fishes, and marine shells in great abundance, consisting chiefly of the genera Voluta, Rostellaria, Fusus, Cassidaria, Aucilla, Buccinum, all existing genera of univalves, though most of the species are extinct. A nautilus, resembling the Nautilus pompilius of the Indian Seas, is also common, but no ammonites and belemnites, so abundant in the chalk. Terebratulæ and Echinida are also rare, as are likewise Zoophyta. Considerable portions of the trunks of trees are found in it, often perforated by Teredines, which shows that they must have been floating some time in the sea, but land must have existed at no great distance to have supplied the immense number of ligneous seed-vessels of plants resembling cocoa-nuts and the spices of tropical climates which are found in the cliffs of the Isle of Sheppey. The remains of crocodiles and turtles also prove the existence of some continent or island, at no great distance, to which these oviparous reptiles could have resorted for the purpose of depositing their eggs. Among the vegetable remains of this formation must be enumerated copal or fossil resin, sometimes met with in small nodules. Organic remains are rare in the lower part of the series; when they occur, they consist chiefly of the genera Murex, Cerithium, Tunitella, and Ostrea, with a slight admixture of the fluviatile genera, Planorbis and Cyclas. Seams of lignite occasionally occur.

The thickness of the London clay, as ascertained by numerous wells and artesian borings, is very variable, and is much less on the eastern than on the western side of London. At Bromley, it is 44 feet; at Tottenham, 77; in St. James's-street, 235; at Wimbledon, 530 and more; at High Beach in Essex, 700 (estimated); at Portsmouth, 102. The greatest height it attains above the sea is at High Beach, 759 feet.

Bagshot Sands.—These rest on the London clay, and consist of ochreous sand alternating with foliated green clay, green sand, and sulphur-yellow, white and pinkish foliated marls. Organic remains are rare, but a few imperfect shells have been found in the marls, of the genera Trochus, Pecten, and Crassatella, which appear to belong to eocene species of the Paris basin. It occupies the surface of Bagshot, Frimby, and Purbright heaths; St. Anne's and Shrubs' hills, west of Chertsey, St. George's Hill, near Weybridge, Chobham Ridges, and Romping Downs, north of the Hog's-back in Surrey, and the Hampstead and Highgate hills in Middlesex. The greatest elevation above the sea is 463 feet.

FRESH-WATER FORMATIONS OF THE ISLE OF WIGHT.

THESE beds were discovered by Mr. Webster soon after the publication of the description of the formations of Paris by Cuvier and Brogniart. He divided them into a lower and an upper fresh-water deposit, separated by a bed containing marine remains; and he gave it the name of the upper marine, considering it the equivalent of the formation of the Paris basin, so named by Cuvier and Brogniart.

The existence of this marine bed was afterwards questioned; but subsequent observations by Professor Sedgwick and Mr. Lyell have established an intercalation of strata, containing a mixture of marine and fresh-water shells between two beds, the organic remains of which appear to have been deposited tranquilly on the spot. The series is exposed in the face of the cliff at Headen Hill, the total thickness of all the strata amounting to about 400 feet, with about 36 feet of the marine formation appearing midway in the cliff. The lower marine is worked in the quarries at Binstead, near Ryde. At Headen, the lower fresh-water formation consists of sand, calcareous and argillaceous marls, containing shells of the genera, Paludina, Potamides, Melania, Cyclas, Unio, Planorbis, and Lymnea, all inhabitants of fresh-water. At Binstead, it consists of limestone, composed of fragments of fresh-water shells, siliceous limestone, and calcareous marls. At the quarries of this place, in the marls alternating with the limestone beds, a tooth of an Anaplotherium and two teeth of a Palæotherium have been found, accompanied by other rolled and broken bones of Pachydermata, and the jaw of a new species of Ruminantia, allied to the genus Moschus.

The marine formation at Headen is about thirty-six feet thick, and consists principally of greenish marl. The shells, according to Professor Sedgwick, are chiefly of the marine genera, Murex, Buccinum, Natica, Venus, Nucula, Corbula, mixed with a few of the fresh-water genera, Cyclas, Potamides, Melanopsis, and Neritina.

The upper fresh-water formation is composed of a yellowish-white marl, inclosing masses which are more indurated, and containing fresh-water shells of the genera, Lymnea, Planorbis, and Helix, together with the seeds of chara, and remains of coleopterous insects. This fresh-water formation is surmounted by a mass of transported gravel.

The lower fresh-water formation, from the phenomena exhibited at Headen Hill, appears to have been deposited tranquilly in fresh water. The mixture of land, marine, and fresh-water shells in the marine bed implies deposit in an estuary; but to produce that estuary there must have been a change of level.

The strata at Hordwell Cliff, on the coast of Hampshire, consisting of alternations of clays and gravels, some of a bluish-green colour, are surmounted, like those of Headen Hill, by a mass of transported gravel. They have afforded scales of a tortoise, seed-vessels of the chara, teeth of a crocodile, and scales of fishes, together with shells of the genera Melania, Melanopsis, Planorbis, Lymnea, Potamides, Neritina, Ancylus, Unio, Mya, and Cyclas.

From the vertical position of the strata of the London clay in Alum Bay, and from the horizontal position of the fresh-water strata in other parts of the island, Mr. Webster inferred that the latter were not deposited till after the upheavement of the former; but Professor Sedgwick has shown that these appearances are deceptive, arising from the local nature of the disturbances at Alum Bay;—that the fresh-water beds are there vertical, as well as the London clay and the chalk, and that wherever they are horizontal the chalk is horizontal also; so that the fresh-water beds were deposited before the chalk was upheaved, and have partaken of its movements.

SIMULTANEOUS METEOROLOGY.—No. V.

TABLE of HOURLY METEOROLOGICAL OBSERVATIONS, made during the 21st and 22nd of Dec., 1837, at Blackheath Road, near Greenwich, about four miles and a half S.E. of London, *by and under the superintendence* of J. H. Belville, in conformity with the Instructions circulated by the South African Literary and Philosophical Institution.

DATE.	HOUR.	BARO-METER.	THERMR.		WIND.		Prop. of Cloud.	STATE OF THE ATMOSPHERE, CLOUDS, &c.
			Attached	In open air.	Direction.	Strength		
		Eng. In.	Fah °	Fahr. °				
Thursday, December 21, 1837.	VI. A.M.	29·760	53	42·4	N.	3	10	Stormy high wind; densely cloudy.
	VII.	29·840	53	42·0	N.	3	10	Ditto. ditto.
	VIII.	29·895	53	42·0	N.	2	10	Clouds broken; more moderate.
	IX.	29·958	52	41·1	N.	2	7	Getting clearer. *Sunshine at intervals.*
	X.	30·020	52	41·2	N. b E.	2	5	Passing drops of rain since last obs.
	XI.	30·080	52	41·2	N.N.E.	2	6	Much driving cloud *scud* from N.N.E.
	XII.	30·110	51½	41·2	N.N.E.	1	6	Wind going down. Air getting dry.
	I. P.M.	30·120	52	42·5	N.N.E.	1	5	Little or no variation.
	II.	30·136	51	41·5	N.N.E.	1	10	The same
	III.	30·153	51	41·4	N.N.E.	1	10	Getting now more overcast, and no wind.
	IV.	30·200	51	41·0	N.E.	1	10	The maximum by a self-registering thermometer 43°·1.
	V.	30·225	50	40·5	N.E.	1	10	
	VI.	30·294	51	40·8	N.ly	1	10	
	VII.	*30·250	52	40·2	E. b S.	1	10	* N.B. Barometer very unsteady for two or three hours.
	VIII.	30·239	51½	39·4	E.S.E.	0	10	
	IX.	30·251	51	40·1	S.	0	10	
	X.	30·292	51	39·2	S.	0	10	A completely covered sky, and no variation in its appearance for these 15 hours.
	XI.	30·268	51	39·1	S.	0	10	
	XII.	30·254	51	39·0	S.	0	10	
Friday, December 22.	I. A.M.	30·250	51	39·0	S.	0	10	
	II.	30·241	51	39·0	S.S.W.	1	10	
	III.	30·208	51	39·1	S.S.W.	1	10	
	IV.	30·182	51	39·5	S.S.W.	1	10	The min. by a self-registering ther. 38°·2.
	V.	30·157	51	40·0	S.W.	1	10	
	VI.	30·150	51	40·6	S.W.	1	10	
	VII.	30·132	51	41·0	S.W.	2	10	Clouds a little broken The lowest of a radiator on the ground, 37°.
	VIII.	30·114	51	42·6	S.W.	2	10	Quite thick.
	IX.	30·100	51	42·9	S.W.	2	10	The same.
	X.	30·090	49	44·1	S.W.	2	10	The same; *scud* swiftly moving from S.W.
	XI.	30·080	50	45·5	S.W.	2	10	The same.
	XII.	30·062	50	46·0	S.W.	2	10	The same; drizzling rain.
	I. P.M.	30·030	51	47·0	S.W.	2	10	The same.
	II.	30·011	51	48·0	S.W.	2	10	The same.
	III.	30·000	51	48·0	S.W.	2	10	The same; sky gets turbid and gloomy.
	IV.	29·981	51½	48·0	S.W.	2	10	The same.
	V.	29·974	52	49·1	S.W.	2	10	The same.
	VI.	29·958	52	49·5	S.W.	2	10	The same.

Notes.—A violent gale all night of the 20th and morning of the 21st, from W.N.W. and N. At 1 A.M., the barometer stood at 29·32, and as the wind got to the N.W. and N., it rose at the rate of above 1-10th of an inch in an hour; the thermometer, at noon on the 20th, rose to 55°, a degree of warmth very uncommon on the day preceding the winter solstice.

A remarkably cloudy period; not a star visible during the whole night. The atmosphere was covered with one mass of dense cloud; the sun, likewise, was not once seen on the 22nd.

The time was taken from a good clock, keeping mean time. Rate scarcely perceptible. Error obtained by observation of the ball-drop of the Royal Observatory, Greenwich.

The Barometer has an elevation of 46 feet above *mean high-water mark* of the river Thames, carefully deduced by very accurate barometrical measurement. The index error of scale presumed to be within a *hundredth* or two of the truth. The Thermometer, by Dollond, suspended in open air, at an elevation of 40 feet from the ground: aspect, northerly.

The comparative strength of wind is indicated by the figures thus,—0 means no wind perceptible; 1, very *light breeze*; 2, strong breeze; 3, a gale. In the column headed *Proportion of Cloud*, 0, signifies quite clear. *10, no* blue sky visible; 5, sky half covered.

NEW PATENTS. 183;

N. B.—The first Date annexed to each Patent, is that on which it was sealed and granted; the second, that on or before which the Specification must be delivered and enrolled.——The abbreviation *For. Comm.*, signifies that the invention &c., is "a communication from a foreigner residing abroad."

DECEMBER.

223. JAMES DOWIE, Frederick-st., Edinburgh, Boot and Shoe Maker; for improvements in the construction of boots and shoes, or other coverings for the human foot. Dec. 2.—June 2.

224. WILLIAM OCCLESHAW, Manchester, *Lanc.*, Leaden Pipe Manufacturer; for improvements in the machinery or apparatus for manufacturing pipes or tubes, or other similar articles, from lead or other metallic substances. Dec. 2.—June 2.

225. THOMAS WILLIAM BOOKER, Merlin Griffith Works, *Glamorganshire*, Iron-Master and Tin-Plate Manufacturer; for improvements in preparing iron to be coated with tin or other metals. Dec. 4.—June 4.

226. GEORGE COTTAM, Winsley-st., Oxford-st., *Middx.*, Engineer; for improvements in the construction of wheels for railway and other carriages. Dec. 5.—June 5.

227. MOSES POOLE, Patent Office, Lincoln's-Inn, *Middx.*, Gent.; for improvements in looms for weaving figured and ornamented fabrics. *For. Comm.* Dec. 5.—June 5.

228. MOSES POOLE, Patent Office, Lincoln's-Inn, *Middx.*, Gent.; for improvements in printing. *For. Comm.* Dec. 5.—June 5.

229. JOHN HALL, Nottingham, *Notts.* Lace Manufacturer; for improvements in machinery whereby cloth or woven fabrics of various kinds may be extended or stretched, and dried in an extended state. Dec. 5.—June 5.

230. JOSHUA TAYLOR BEALE, Church-lane, Whitechapel, *Middx.*, Engineer; for improvements in and additions to his former invention, known by the title of a lamp, applicable to the burning of substances not hitherto usually burned in such vessels or apparatus, and secured to him by letters-patent, dated Feb. 4, 1834.

231. SAMUEL MILLS, Darlaston-green Iron and Steel Works, near Wednesbury, *Staff.*, Iron Master; for improvements in machinery for rolling metals. Dec. 9.—June 9.

232. JEREMIAH BYNNER, Birmingham, *Warw.*, Lamp-Maker; for improvements on lamps. Dec. 9.—June 9.

233. BENJAMIN COOK, Birmingham, *Warw.*, Brass Founder; for an improvement in gas-burners, commonly called or known by the name of argand burners. Dec. 9.—June 9.

234. CORNELIUS WARD, Great Tichfield-st., Marylebone, *Middx.*, Musical Instrument Maker; for improvements on the musical instruments designated drums. Dec. 9.—June 9.

235. THOMAS VALE, Allen-st., Lambeth, *Surry*, Coach Joiner; for improvements in hinges. Dec. 13.—June 13.

236. JAMES HUNTER, Leys Mill, Arbroath, *Forfar*, Mechanic; for a machine for boring or perforating stones. Dec. 13.—June 13.

237. WILLIAM ELLIOTT, Birmingham, *Warw.*, Button Manufacturer; for improvements in the manufacture of covered buttons. Dec. 14.—June 14.

238. THOMAS JOYCE, Camberwell New-rd., *Surry*, Gardener; for improved apparatus for heating churches, warehouses, shops, factories, hothouses, carriages, and other places, and improved fuel to be used therewith. Dec. 16.—June 16.

239. JOSHUA JOHN LLOYD MARGARY, Wellington-rd., St. John's Wood, *Middx.*, Esq.; for a new mode of preserving animal and vegetable substances from decay. Dec. 19.—June 19.

240. JOHN GRAY, Liverpool, *Lanc.*, Engineer; for improvements in steam-engines and apparatus connected therewith; particularly applicable to marine engines for propelling boats or vessels, and parts of which are also applicable to locomotive and stationary steam-engines and other purposes. Dec. 19.—June 19.

241. EDMUND BUTLER ROWLEY, Manchester, *Lanc.*, Surgeon; for improvements applicable to locomotive-engines, tenders, and carriages, to be used upon railways, and which improvements are also applicable to other useful purposes. Dec. 19.—June 19.

242. JOHN WHITE, Manchester, *Lanc.*, Engineer; for improvements in apparatus usually employed in lathes for turning

metals and other substances. Dec. 19.—June 19.

243. James Berington, Winckworth-pl., Shoreditch, *Middx.*, Gent., and Nicholas Richards, Camomile-st., *Lond.*, Builder; for improvements in curing or preventing smoky chimneys; also applicable to the purposes of ventilation. Dec. 19.—June 19.

244. Christopher Nickels, Guildford-st., Lambeth, *Surry*, Gent.; and Henry George Collins, Queen-st., Cheapside, *Lond.*, Bookbinder; for improvements in bookbinding, parts of which improvements are applicable to the cutting paper for other purposes. Dec. 19.—June 19.

245. John Robertson, Jun., Great Charlotte-st., Buckingham-gate, *Middx.*, Gent.; for improvements of architecture as regards its construction, or in the description or properties of the forms and combinations, and also of the superficial figures which may be employed; the application of these improvements being also for supplying forms, figures, or patterns, in various arts or manufactures; also for improvements with regard to the surfaces of buildings whether interior or exterior, for protecting them from decay, and also giving them a more finished appearance. Dec. 19.—June 19.

246. William Henry Pitcher, Billiter-sq., *Middx.*, Merchant; for improvements in the construction of docks, and apparatus for repairing ships and vessels. Dec. 19.—June 19.

247. Neale Clay, West Bromwich, *Stafford.*, Manufacturing Chemist; for improvements in the manufacture of iron. Dec. 19.—June 19.

248. William Sandford Hall, Strathearn Cottage, Chelsea, *Middx.*, Lieutenant in the Army; for improvements in paddle wheels. Dec. 19.—June 19.

249. William Henry James, Birmingham, *Warw.*, Civil Engineer; for improvements in telegraphic apparatus, and in the means of communicating intelligence by signals. Dec. 22.—June 22.

250. John Elvey, Canterbury, *Kent*, Millwright; for improvements in paddle wheels. Dec. 23.—June 23.

251. William Lash, Benton-hall, *North.*, Esq.; for improvements in decomposing muriate of soda, (common salt) parts of which improvements are also applicable to the condensing vapours of other processes. Dec. 23.—June 23.

252. Charles Button, Holborn-bars, Chemist, and Harrison Grey Dyar, Mortimer-st., Cavendish-sq., *Middx.*, Gent.; for improvements in the manufacture of white lead. Dec. 23.—June 23.

253. William Brindley, Birmingham, *Warw.*, Patent Paper-tray Manufacturer; for improvements in the construction of presses. Dec. 23.—June 23.

254. Jehiel Frankling Norton, Manchester, *Lanc.*, Merchant; for improvements on stoves or furnaces. *For Comm.* Dec. 23.—June 23.

Patent-Law Grievance. No. XXII.

The inventors of this country, and the introducers of inventions of other countries into this, were obliged to pay down to the attorney-general and other agents, &c., of the Government, during the ten years ending December, 1834, more than £313,000, and during the past year above £42,000 (being at the rate of £420,000 in ten years.) It is to be observed that these enormous extortions are *exclusive* of the drawings, engrossings, and all the other charges of the patent-solicitor.

The penalties inflicted on the inventive genius of Britain during the *present* year, up to the 25th ult., in the shape of government stamps and fees on patents, amount to more than £40,000!

N.B. This sum has been paid in *ready money* on taking the first steps, and as many of the inventors are poor men, (*Operatives*,) and a great many others of them persons to whom it would be very inconvenient to pay at least £100 down, they have been obliged to go into debt, or mortgage or dispose of their inventions, either wholly or in part, &c.

METEOROLOGICAL JOURNAL FOR NOVEMBER, 1837; KEPT AT BLACKHEATH ROAD.

Day of Month	Barom. 9 A.M.	Ther attch.	Barom. 3 P.M.	Ther. attch.	Thermometer		Daily Temp	Solar Var.	Rad.	Clouds.		Winds.		Direction of Wind		Lunation.	WEATHER, &c.
					Min.	Max.				A.M.	P.M.	A.M.	P.M.	A.M.	P.M.		
Wed. 1	29·048	56°	28·848	59°	39°2	56°9	48°1	17°7	37	10	10	4·5	3	WSW	WSWW		Rain at 7 A.M.; a gale; evening and night more moderate.
Thurs. 2	29·200	56	29·208	57	39·6	49·0	44·3	9·4	39	5	5	4	3·1	W	W		Squalls, wind high; *lightning* at night.
Friday, 3	29·307	52	29·366	54	32·3	47·4	39·9	15·1	28½	3	2	1·2	1	WSW	wbs		Hoar frost; *Cirri*; clear; *evening, frequent lightning.*
Satur. 4	29·742	50	29·885	52	32·6	46·5	39·6	13·9	29	5	5	2	1	wbN	NW		*Cumuli*; fine weather.
SUN. 5	30·112	51	30·110	52	32·4	47·6	40·0	15·2	29	8	8	1	1	W	wbN	☽	Cloudy at intervals; an *extensive aurora* all night.
Mon. 6	30·350	50	30·396	52	32·2	44·4	38·2	12·2	29	3	6	1	0	Nbw	E		Fine, *Cirro-Cumuli*; fog at night with frost.
Tues. 7	30·496	48	39·448	50	26·1	42·5	34·3	16·4	26	1	0	0	0	S	SE		Dense fog till 9 A.M.; cloudless.
Wed. 8	30·369	47	30·295	48	23·8	37·0	30·4	13·2	23	10	0	0	—	E	—		Frost, with fog and rime; clear, fog at night.
Thurs. 9	30·215	45	30·108	47	20·4	45·1	32·8	24·7	19½	5	10	2	2	SW	SW		Do.; *Cirrus* and *Cirro-cumulus*; rain P.M.
Friday, 10	30·020	51	29·970	54	43·0	53·0	48·0	10·0	37	10	10	2	2	WSW	wbs		Damp, with small rain; *Scud.*
Satur. 11	29·996	54	30·010	55	46·0	53·5	49·7	7·5	43	7	5	2·3	2	WSW	wbN		Wind in squalls; cloudy.
SUN. 12	30·085	53	30·130	55	40·4	44·2	42·3	3·8	38	3	2	2	1	NW	NW	○	Fine, *Cumuli*; a fine *crimson aurora* at night.
Mon. 13	30·165	53	30·100	55	32·0	45·0	38·5	13·0	29	8	10	1	0	W	SW		Overcast; evening, rainy and foggy.
Tues. 14	29·608	54	29·530	54	42·9	48·2	45·6	5·3	40	7	2	2	1·3	wbN	WNW		Mostly cloudy; light rain.
Wed. 15	29·986	50	30·058	52	33·9	43·5	38·7	9·6	32	5	2	2	1	N	NbE		*Cumuli*, a squall at noon; a brilliant *aurora* at night.
Thurs. 16	30·057	49	30·000	50	31·0	40·1	35·5	9·1	29	3	4	1	0	NE	ENE		Fine.
Friday, 17	30·032	47	30·051	48	25·8	40·9	33·3	15·1	20½	5	6	0	2·1	NbE	NbE		Frost, till 10 A.M.; cloudy at intervals.
Satur. 18	30·196	45	30·102	46	26·4	42·8	34·6	16·4	25	10	10	0	2	SW	WSW		Frosty, *a red sun-rise*; eve cloudy, with small rain.
SUN. 19	30·058	51	29·970	53	39·0	52·7	45·8	13·7	37	6	9	2	2	swbw	SW		Mild windy weather.
Mon. 20	29·910	55	29·801	56	41·1	48·0	44·6	6·9	40	0	2	3	2	WSW	SW	☾	Clear A.M.; *Cirro-Stratus*; night clear, faint *aurora.*
Tues. 21	29·904	52	29·910	53	33·0	47·2	40·1	14·2	30	2	7	2·3	2	WSW	W		Very clear A.M.; P.M. squally; cloudy night.
Wed. 22	29·985	54	29·950	56	38·2	55·0	46·6	16·8	35	10	10	3	3	WSW	wbs		*Cirro-Stratus* and *Scud*; wind high.
Thurs. 23	29·852	56	29·759	58	51·0	53·9	52·5	2·9	48½	10	10	3·4	1	WSW	SW		Dark windy weather; great deposition of moisture.
Friday, 24	29·986	57	30·000	57	43·5	48·1	45·8	4·6	41½	10	9	0	0	var.	E		Cloudy; showery and misty.
Satur. 25	30·126	54	30·185	54	35·5	40·8	38·2	5·3	33	5	0	1	0	NE	NE		Cloudy A.M.; fine.
SUN. 26	30·100	49	29·775	52	27·7	47·0	37·4	19·3	26	7	10	2	3	SW	SW		Stormy indications; P.M. rain and wind.
Mon. 27	29·584	59	29·550	51	33·5	42·6	38·0	9·1	30	1	5	1	2	WSW	wbN	●	Cloudless till noon; *Cumuli* and *Cirro-Cumuli.*
Tues. 28	29·350	51	29·278	51	38·5	44·1	41·3	5·6	36	10	9	2	1	W	WNW		Clouds of all *modifications*; night alternately showery and clear.
Wed. 29	29·545	47	29·690	49	30·2	38·4	34·3	8·2	29	0	0	1	1	WNW	wbN		Cloudless; *aurora* at night.
Thurs. 30	29·745	47	29·696	50	28·1	48·8	38·5	20·7	25	9	8	2	2·3	SSW	SSW		*Cirro-Stratus, Scud*; drizzling rain.
Mean.	29·904	51	29·873	53	34·64	46·48	40·56	11·83									

Bar. Max. 30·496 on the 7th.
Bar. Min. 28·832 „ 1st.

Ther. Max. 56·9° on the 1st.
Ther. Min. 20·4° „ 9th.

Lowest point of Rad. 19½°, on the 9th.
Rain fallen (by Crossley's self-registering gauge), 1·750 in.

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